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THE CENTRAL GREAT PLAINS.*

The United States Geological Survey has for a number of years been studying the underground waters which are flowing hundreds of feet beneath the surface in many sections of the Central Great Plains, including the greater portions of South Dakota, Nebraska, and Kansas, and the eastern portion of Colorado and of Wyoming, an area of about one-half million square miles. In order that we may make the best possible use of the underground "rivers" which it is believed flow perhaps continuously for some hundreds of miles, it is necessary to understand the structure and stratigraphy of the water-bearing formations. The question of water supply, both over-ground and underground, is one of great interest to the people in this district, and although considerable progress has been made in some sections in developing well waters, there are vast areas in which the present supplies are inadequate, even for local domestic use.

The investigation has been in charge of Mr. N. H. Darton, who has recently brought together the results of the work in a handsome quarto volume of 400 pages published by the Survey, and entitled "Geology and Underground Water Resources of the Central Great Plains." Mr. Darton gives an excellent geologic history of the region, describing not only those sections which conceal water far down in the earth, but also those places which are dry below as well as above. Smooth surfaces and eastward-slop-

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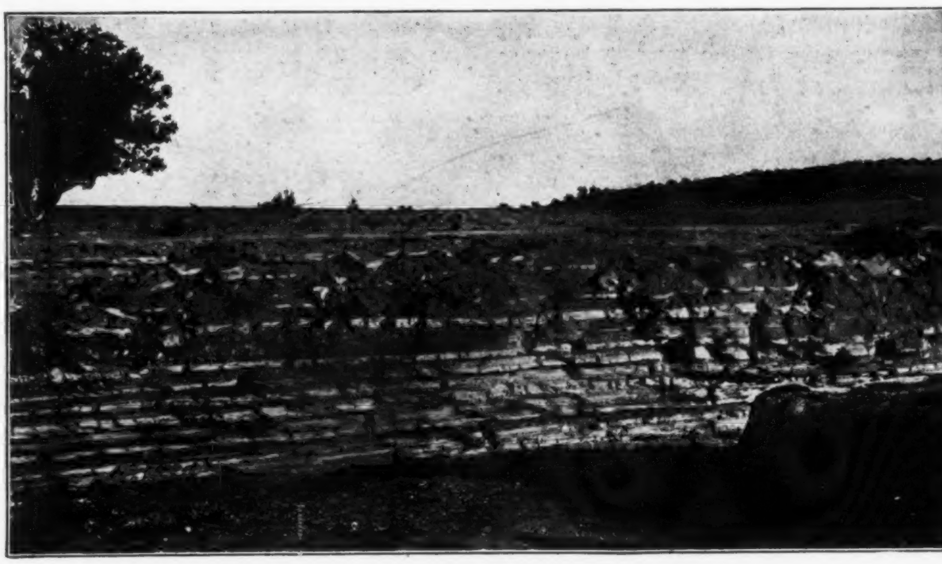

GREENHORN LIMESTONE IN BENTON GROUP NEAR THATCHER, COLORADO.

View showing alternation of limestone and shale. Photograph by G. K. Gilbert.

Photos by N. H. Darton, U. S. Geological Survey.

CATHEDRAL SPIRES, GARDEN OF THE GODS, COLORADO.

Vertical Strata of lower Wyoming red grits. Looking north.

ARCHWAY ERODED IN MONUMENT CREEK SANDSTONE, AT "ELEPHANT ROCK," NEAR MONUMENT, COLORADO.

Showing massive character of sandstone.

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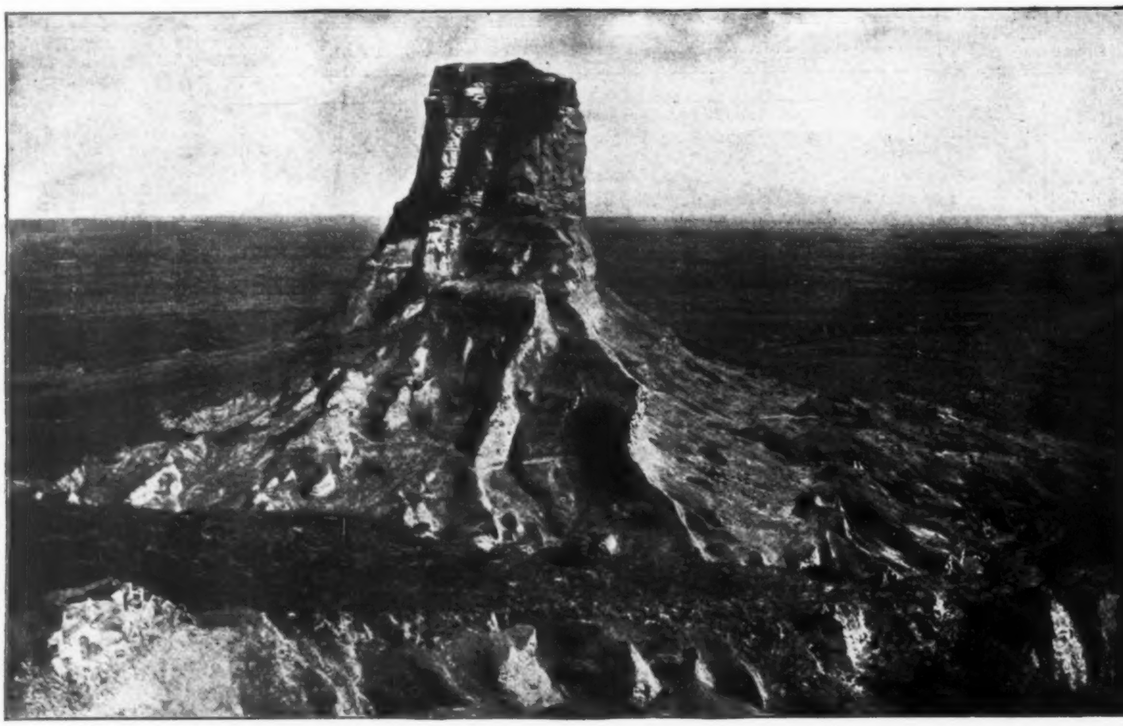
ing rolling plains are the characteristic features of the region, but in portions of the province there are buttes, extended escarpments, and local areas of badlands.

The report reproduces more than one hundred beautiful photographs by Mr. Darton of different scenes in the Great Plains. Several of these are given here. The thick succession of sedimentary formations underlying the Great Plains includes porous strata containing large volumes of water. These water-bearing deposits comprise widespread sheets of sandstones or sand, from Cambrian to Tertiary in age. The sandstones of the older formations are in sheets often several hundred feet thick, alternating with bodies of of impermeable deposits, the waters are under great pressure, for the intake zone has an altitude of from 4,000 to 6,000 feet and the region of outflow is only from 1,000 to 1,200 feet above sea-level. The existence of this pressure, as found in many wells in eastern South Dakota, is the strongest evidence we possess that the waters flow underground for many hundreds of miles. Several wells show surface pressures over 175 pounds to the square inch and two are slightly over 200 pounds, the latter indicating a pressure of 780 pounds at the bottom of the well. In South Dakota the Dakota sandstone carries a large volume of water, which has been extensively utilized by artesian wells. as that of many other wells in the State. It furnishes power for a sixty-barrel flour mill by day and for an electric-light plant by night. For a while it threw sand, and when this finally ceased the flow was thought to have slightly decreased.

It is believed by some persons that owing to this great draft upon the resources the available supply is diminishing, but there is as yet no valid evidence that this is the case, excepting locally where there are numerous wells. Individual wells often diminish in efficiency owing to leakage, clogging, and other causes, but ordinarily new wells in the same vicinity show the same pressure and flow as were found in the older



JAIL ROCK.

Showing castellated form of weathering of Gering sandstone; slopes of Brule clay. Valley of North Platte in distance. View from Court-house Rock. Looking east.

Photos by N. H. Darton, U. S. Geological Survey.

ARTESIAN WELL AT WOONSOCKET, SOUTH DAKOTA.

This well throws a 3-inch stream to a height of 97 feet.

ARTESIAN WELL AT LYNCH, NEBRASKA.

This well has a flow of 3,100 gallons a minute from an 8-inch casing, with a pressure of 85 pounds to the square inch. A first flow was found at 740 feet and a second at 875 feet.

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relatively impermeable shales or limestones, so that they present favorable conditions as water-bearers. To the west they are upturned by the great uplifts and outcrop along the high mountain slopes; to the east most of them rise gradually to the surface, while in the central and northern regions they lie at great depth under the heavy mantle of younger deposits.

Part of the surface water passes into the sandstones in their elevated outcrop zones along the foot of the western mountains and flows east through the permeable rocks, in most cases finally escaping in springs in the low-level areas of outcrop eastward and southward. In such water-bearing strata as the Dakota and underlying beds, which are overlain by a thick mass This water is under pressure so great that in the eastern portion of the State flows are obtainable in all but the very highest lands, except in the southeast corner, near the zone, where the head is lost by the sandstone reaching the surface. Over a thousand deep wells have been sunk east of the Missouri River, most of which are from 500 to 1,000 feet in depth and generally yield a large supply of flowing water, much of which is used for irrigation. The aggregate flow from these wells is estimated to be about 7,000,000 gallons a day.

The illustration on this page shows a remarkable well. Another phenomenal well in the same State is a well at Springfield, which has a flow of 3,292 gallons per minute, although its closed pressure is not so great ones; but it is probable that if this large flow is permitted to continue, the available volume of artesian supply will eventually be greatly diminished.

The source of water is believed to be in the Black Hills and in the Rocky Mountains, for the sandstone appears to be a continuous stratum or a series of strata, permeable throughout, and containing water which to the east has much of the initial head or pressure due to the high altitude of the zone of intake on the mountain slopes. There are extensive areas in central South Dakota in which the underground waters have not yet been developed. Apparently in these areas the Dakota standstone lies deep, but not at an impracticable depth for well-boring. Probably further

drilling will show that flowing waters may be obtained all the way up Cheyenne Valley and its two branches to the Black Hills, and up the valleys of White, Bad, and Owl rivers, nearly to longitude 102 deg.

The Central Great Plains region presents considerable variety of climate. To the east, on the plains, the precipitation varies from moderately humid to nearly arid, the change taking place gradually from east to west. To the east there are 40 inches of rainfall per year, while to the west, in the region adjoining the Rocky Mountains and the other ranges, there are less than 12 inches over an area of considerable extent. To the east the precipitation is ample for crops, and that portion of the region is one of the greatest producers of corn, wheat, and other agricultural products in the world, while to the west there are broad tracts in which no crops can be produced without irrigation. On the mountains in the western portion of the area there is locally increased precipitation, which in many areas is sufficient for agriculture. The amount of water that falls in the arid area is enormous when the number of cubic feet per square mile is calculated, but much of it comes in very heavy showers, after long intervals of drought, often with severe hot winds. If a portion of the rainfall could be stored, much of it could be used for irrigation.

Photos by N. H. Darton, U. S. Geological Survey.

PULPIT ROCK, KANSAS.

An outcrop of Dakota sandstone.

BIG BADLANDS, SOUTH DAKOTA, EAST OF FLOUR TRAIL.

Characteristic rounded forms of Chadron clays, overlain by Brule clay (Oredon beds) in distance; remnants of plateau out of which Badlands were carved in foreground and in outlying buttes. Looking east.

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SOLUBILITY OF FRAGRANT VEGETABLE SUBSTANCES.

PROF. CHARABOT and Prof. Herbert, of Paris, have lately performed experiments with regard to the solubility of fragrant substances of vegetable origin, and have given the results of their investigations in a lecture delivered in the Académie des Sciences. Charabot and Lalone had previously observed, in examining the odorous constituents of the mandarin and the bitter orange, that the perfume contained in the stem of the tree, in an advanced state of growth, was less soluble than that in the leaves. Whether this is universally true, or only in the case of these special plants, the investigators set themselves to discover. *Ocymum basilicum*, *Citrus madurensis*, and *Citrus bigardia* were examined. It was proved that when the organs are fully developed, the largest amount of soluble matter, both organic and mineral, is contained in the leaves, and the smallest in the root. It was further determined, in general, that during the period of development of an organ, the quantity of soluble matter is reduced, the reduction, however, seeming to be less in the leaves. The investigators reached the conclusion that the difference in the solubility between stem and leaf substance is in general the same, and varies in the same way, as in the extracts made by Charabot and Lalone. Root and stem are of less soluble material. In the leaf the solubility of the organic substances—as of the whole substance—undergoes no great change after a certain period of growth. The process of assimilation, doubtless, keeps the balance of organic matter here. If a given substance changes its character, if it becomes insoluble, or if it passes to some other organ, it eventually returns, by reason of the continuous work of the chlorophyl. In the stem, the diminution of solubility of organic matter seems to be due to the formation of less soluble compounds, or to the carrying away of soluble compounds to other organs, which may be in process of formation. This is especially the case in the time of blossom, when the plant has such an important function to perform. At this time the osmotic pressure drives the liquid material to the blossom, which contains a large amount of aqueous matter.

THE BANANA.*

By MEL T. COOK, Director of the Division of Vegetable Pathology of the Cuban Agricultural Experimental Station.

THE tropical countries have a rather mysterious fascination for most of us. We usually think of them as lands of sunshine, birds, flowers, and delicious fruits. Our ideas of the fruits are formed from our limited knowledge of the banana, orange, and pineapple. As a matter of fact, the tropical fruits are no more delicious than fruits from northern countries, and the traveler must frequently acquire a taste for them before they can be enjoyed.

In this series of short articles on "Tropical Fruits" the banana will be considered first because it is one of those with which the readers of School Science and Mathematics are most familiar. Only a few years ago the banana was a luxury in many northern families. Although fairly common on the city markets, it was too expensive to be generally used by most families living in and near the small towns; but now so abundant and cheap as to be a common article of commerce in every corner grocery store, while in the cities it is frequently referred to as the poor man's fruit. There are probably more bananas shipped into the United States than all other tropical fruits combined. Despite the commonness of this fruit, few of us have more than a vague knowledge of its character and habits.

It belongs to the family *Musaceae*, and is a native of the eastern tropical countries, but has been introduced into practically all moist tropical countries. Most of the species are grown for fruits, a few for fiber, and a few as ornamental plants in sub-tropical countries or in greenhouses in cold countries. It thrives best in moist lowlands, and since most species and varieties seldom or never produce seeds it is necessary to propagate it from suckers which are being continually produced from just beneath the surface of the ground. In a well cultivated field three or four plants of different ages are allowed to stand in a cluster. The plant bears fruit in from twelve to eighteen months. Each plant fruits but once, and when the fruit is harvested the old stalk is destroyed, the young plants being allowed to remain. Thus a continuous crop can be produced without replanting, so long as the soil maintains its fertility, which is about four to six years.

Under the most favorable conditions the plants may reach twenty feet in height. The leaves are bright green, elliptical, pinnately-parallel veined, with sheathing petioles which form a false stem-like structure. The flowers are borne in a dense terminal raceme rising on a stalk through the false stem. They are unisexual and are borne in clusters (two rows in each cluster), and each cluster is covered by a large, dark-red bract. About one-fourth of the cluster at the base of the raceme contains only pistillate flowers while all others contain only staminate flowers. The bracts successively turn back, exposing the flower clusters. Each flower has a six-parted perianth, five parts united into one piece and known as the calyx, and one part single and known as the corolla. However, it is probable that two parts of this so-called calyx are really parts of the corolla. There are five stamens and a three-chambered inferior ovary. In the pistillate flowers the ovary is $3\frac{1}{2}$ to 4 inches long, the other parts of the flower about $1\frac{3}{4}$ inches in length, and the stamens atrophied. In the staminate flowers the ovary is atrophied, being only about $\frac{3}{4}$ inch long, and the other parts about 2 inches in length, with well developed stamens.

When the plant is ready to bloom the bracts turn back successively, exposing the cluster of white flowers; the pistillate flowers being near the base of the raceme bloom first. As the successive clusters open the rachis continues to lengthen and the staminate flowers wither and fall, thus exposing a long rachis bearing on its tip the still active buds. The fruits bend at the point of their attachment with the rachis in such a manner that they point upward.

The edible banana is *Musa sapientum* Linn. and can be grown in all moist tropical countries. A few are grown in Florida, Louisiana, and other States on the Gulf coast. There are a great many varieties of this species; the variety most commonly sold in the United States is the "Johnson," which is imported from Jamaica, Cuba, and Central America. The fruit is not gathered when mature, but while yet green, and is partially ripened in shipping. Like all other tropical fruits, it ripens readily in dark, warm places.

Musa textilis is a native of the Philippines, where it is extensively grown for its fiber, which is sold on the market as Manila hemp. It is grown in dense groves and the plants are frequently twenty feet high. The fruit is not edible, but produces an abundance of seeds, which germinate readily. All the species produce good fibers, but none in such great abundance or of such quality as *M. textilis*. Many other species also produce fruits which are not only used as raw foods, but are also cooked and prepared into very palatable dishes. Banana flour has been made successfully, but as yet it is not a practicable product.

* School Science and Mathematics.

USE OF THE RED GUM FAST INCREASING.

THE market demand for red gum—one of the commonest trees on the hardwood bottomlands of the Sutheastern States and the Mississippi Valley—has grown very rapidly in the last six years. Previous to this time the manufacture of the wood had remained in the experimental stage, little effort having been made to prevent its tendency to warp and twist. Judicious care in handling has, however, proved sufficient to eliminate this objectionable quality, and the usefulness and abundance of the red gum, with the growing scarcity of poplar and cottonwood, which it resembles in several ways, have brought about its increasing use by the mills, until now furniture factories in cities alone consume between forty million and sixty million board feet a year, and the wood may be regarded as firmly established in the market.

Bulletin 58 of the Bureau of Forestry, just published, is the fruit of a thorough study of the red gum and of its value for various purposes. At a time when new woods are sought for substitutes for those of which the supplies have been depleted, such studies are in request among lumbermen and wood manufacturers. Knowledge of the red gum will be especially welcomed by them in view of the plentiful supplies of the timber and the particular need of a wood possessing its qualities.

The red gum grows in mixture with ash, cottonwood, and oak on the deep, fertile alluvial soil of the southern bottomlands, where it is often the commonest timber tree. In the best situations it reaches a height of 150 feet and a diameter of 5 feet, though such very large dimensions are unusual. The stem is straight and cylindrical, furnishing clear wood in wide boards. Most of the best grades are exported, the rest being used here for such purposes as inside finishing and flooring.

The value of the red gum was fully appreciated abroad before a demand for it was felt here. Practically 75 per cent of the clear-heart lumber cut in this country still finds its way to England, France, and Germany, to be manufactured into furniture, inside finishings, newel posts, stair railings, and the like. The commons and other clear sap go here into furniture, desks, the better grade of boxes, and a number of novelties; the poor stock into boxes and other articles for which short, narrow boards are suitable. Red gum is now one of the leading woods used for slack barrels and pails. Nearly all the manufacturers of staves and headings in the Mississippi Valley are using it.

The natural color of the wood is attractive, but it takes stain so well that it is often made to imitate mahogany, walnut, and other favorite woods.

These are only some of the uses of red gum; others will be found as the wood becomes better known.

Since yellow poplar and cottonwood have become scarce and higher in price, it has been found profitable to devote to red gum the particular care in handling which is needful to season it. By piling the lumber so as to secure free ventilation, and allowing it to stand from three to six months, the mills are now able to furnish fairly clear, straight boards. The added cost is not great enough to offset the gain.

"The Red Gum" is the title of Bulletin 58, which may be had upon application to the Forester, Department of Agriculture, Washington, D. C.

THE SPIDER AND HIS WEB.

By Maurice Koechlin.

If we compare the dimensions of the spider with those of its web, we are forced to admit that the little creature is a true engineer, able to construct a cable network of relatively enormous size. Thread after thread is put in position in the desired and necessary order, and sometimes prolonged observation on the part of the investigator is required in order to understand the reasons which direct the spider in its complicated operations, and which make it always follow the same order and the same laws. Some of these reasons are explained by geometry, others by the strength of materials, and he who succeeds in discovering the "why" of all the interesting details of the method employed is compelled to admit to himself that he could not have achieved so good a result with the same materials.

Let us remember, in the first place, that the spider has in its body glands which secrete and expel, through numerous orifices, a viscous matter in the form of threads. As soon as these threads are formed, they acquire, through exposure to the air, a tensile strength as great in proportion to their diameter as that of steel wires, and they also have the elasticity of india rubber. Their surface is sticky and, therefore, they readily adhere to each other.

On the web in process of construction the spider supports itself by the aid of all its feet except the hindmost pair, which it employs in manipulating the thread. But when the little animal wishes to hoist to its nest a weight, such as a fly-pupa, which it carries slung behind, the hind feet grasp the support, and the front feet, like a man's hands, haul in the suspending cord.

Let us now analyze a web. It is composed of three parts: a frame suspended in space, a series of lines which radiate from a common center and terminate in the frame, and, finally, a long spiral thread which makes many turns around this center. The suspension of the frame is the most difficult problem met with in web building and the solutions of it are of infinite variety. First of all, however, the site must be selected —preferably one exposed to the morning sun and on a thoroughfare frequented by the race of winged insects. After a spot which meets these requirements has been chosen, suitable points of attachment must be found. These are always necessarily separated by a chasm which must be crossed without the aid of a rope at least once before the first thread has been laid.

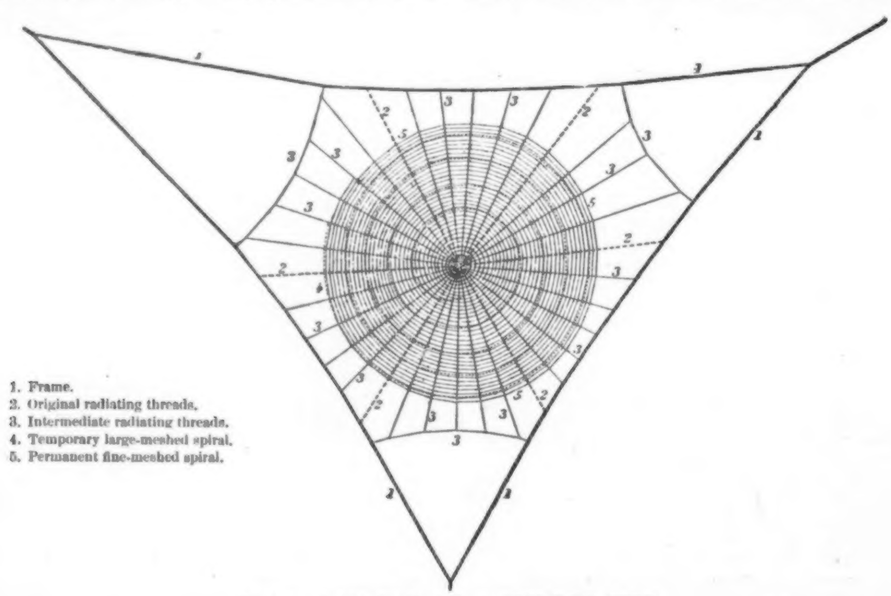


Fig. 1.—DIAGRAM OF A SPIDER'S WEB.

One great principle which the spider never forgets is that it must always spin behind it a thread which will enable it to regain its point of departure, serving both as a guide and a path for the return journey. As a consequence of this principle, the initial point of departure, the center of the first operations, is located at the top of the web, or even far above it, so that it dominates everything. From this point the explorer lowers itself on its inseparable thread, hovers in the air and, if it does not find the desired point of attachment, remounts the thread which it absorbs as it ascends. There are necessarily tentative operations at first; there are useless threads and threads which serve as scaffolds and footways, but no auxiliary thread is ever allowed to remain in the finished web.

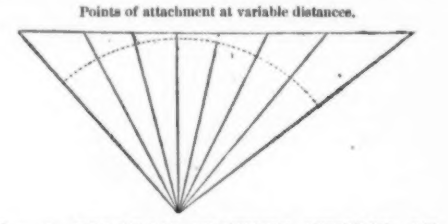


Fig. 2.—DIAGRAM SHOWING METHOD OF ATTACHMENT.

The greatest difficulties exist only for the first web. Afterward the web of yesterday serves as false work for that of to-day and is carefully removed as soon as its usefulness is over. The spider determines the tension of the threads by feeling and can thus both stretch them as their position requires and strengthen those which, in the course of construction, are found to be too heavily laden. It is not rare to see the builder interrupt the normal course of the work, in passing a thread, to reinforce it by doubling, and then resume the ordinary operations. Careful examination of webs shows, furthermore, that the sizes of the threads are proportional to the loads imposed upon them. A ruptured thread is never seen.

In favorable weather a new web is made every night, except when the day's catch has yielded food enough for the morrow and in old age when corpulence has diminished the spider's activity and made it less regular. The web is useless after the first day, for it quickly loses the elasticity and adhesiveness which make it so marvelously efficient as a trap.

The dimensions of webs are proportional to those of their builders. The spider begins to spin webs soon after birth and in the spring multitudes of newly-hatched spiders may be seen working, close together, on webs about half an inch square.

To return to the construction of the web after the framework is laid. The most practical method would seem to be to lay the first transverse thread and then proceed around the circle, laying the radiating threads in regular order, but this would result in stretching them very unequally, so the little engineer adopts a more rational procedure. First, it lays a few radiating threads, say five, spaced at equal angular distances around the circle, and then fills up the gaps with numerous intermediary threads, taking care, as soon as one is laid, to balance it by another diametrically opposite. In this way the defect of inequality of tension is entirely obviated. The ingenious builder endeavors always to keep the same angle between two consecutive radii. This necessitates calculation, for the rays which terminate in one of the lines of the frame are inclined to it at progressively increasing or decreasing angles and the distances between their points of attachment obey a geometrical law which the spider always follows, sometimes with mathematical exactness. From the dimensions of a very carefully constructed web I made a plan with the aid of a millimeter scale, and I found my drawing to agree exactly with the work of my little colleague.

When all the radial lines are in place the spider returns to the center and touches each of the threads as if counting them, but the real object of this maneuver is to ascertain if any are missing. If, by inadvertence, too large a space has been left between two successive threads, a supplementary thread is added to fill the gap. Here is another interesting detail. If some of the radial threads would be excessively long if extended to the frame, in consequence of the small angle which they make with the latter, another transverse thread is added, to which they are attached. The last part of the work, the construction of the long spiral, requires patience, for the spiral makes many turns around the center and each turn must be fastened to all the radiating threads. As the latter, in consequence of their elasticity, are very mobile, they must be held fast during the operation. Just as a seamstress, in joining two pieces of cloth, begins by basting them together at a few points, so the spider bastes its web with a temporary, large-meshed spiral which serves as an aid and guide in forming the permanent fine-meshed spiral. As the work proceeds, the basting threads are carefully removed as they are encountered.

Still other precautions must be taken to insure the equal tension of the threads and to keep the radial lines straight, without bends. The wonderful little creature proceeds as follows: In order to regulate the distance between successive turns of the spiral it keeps one hind foot on the turn just completed, and grasps with its fore feet the radial lines which are to be fastened to the new thread, the tension of which is adjusted by the other hind foot.

The activity of the spider is not incessant. There are periodical intervals of rest, after which the work is resumed at the exact point at which it was left. When, at last, the web is finished and glistens, perfect and brilliant, in the sun, the spider, satisfied with its work, establishes itself in the center or mounts one of the suspending cables to a more elevated nest in a curled leaf, and there awaits its prey.—Translated for the Scientific American Supplement from Sciences, Arts, Nature.

THE INK-FISH.

The fisherman sometimes finds, when he is hauling his lobster pots about this time of year or a little earlier, that masses of soft, transparent, finger-like structures have become entangled in the meshes of one or more of the pots. Large numbers of these are usually obtained attached together by one end like a bundle of small white paraffin candles tied to one another by the wicks. The fact that they are got in this way on the outside of the lobster pot suggests that they are not attached to any object at the bottom, but are carried about by the currents, or at all events, that they are very liable to drift from their moorings. The merest inspection will show that they are egg-capsules, and, if development has proceeded far, it will not only be possible to say that they are the egg-capsules of one of the near allies of the octopus, which occur in our waters—in other words, a cephalopodous mollusk—but that they belong to the common ink-fish, or squid, or calamary, to mention the various names by which the creature is known. Each capsule contains about 150 eggs, and each of the eggs is liable during the five or six weeks of the hatching period to pass through a wonderful series of changes. Within that tough gelatinous capsule the embryos are safe from the enemies which may be supposed to pursue them actively when they are hatched, and *en masse* they are not, nor do they look appetizing to the larger fishes.

The Egg.—At the beginning of development there is nothing to be seen but the relatively large—some three-sixteenths of an inch—transparent ovum, filled with a clear yolk, and the advancing rim of the layer which is forming on the animal pole. A little later this upper portion of the egg shows swellings and ridges—centers of accelerated development in which we already recognize adult features and organs. The body or visceral mass appears in the center, the eyes in front with the head folds, the gills at the side, the arms as knob-like outgrowths. As the visceral mass is raised up from the egg the head is given room to take its place below, the arms extend a little more over the yolk, which, now constricted next the embryo, begins to look like a yolk sac, as it certainly is at least functionally. If it were absolutely logical we should want to turn this figure upside down, for the tentacles of the ink-fish really correspond to the foot of the limpet and other gasteropodous mollusca. But it is convenient as it is conventional to regard the head and the eyes as being the upper portion of the body. The remains of the egg are to be seen above, forming the yolk sac. It is encircled by the tentacles or arms upon which the suckers have already been formed. This is succeeded by the head with the two prominent eyes, and by the body or visceral mass surrounded by the mantle, and furnished already with the terminal fin so characteristic of the adult.

Migrations.—It takes about three weeks more for the further growth of the body and of the head which precedes hatching. This is done at the expense of the yolk, which is used up in the process. The little squid frees itself from its capsule, in the inshore waters, and it remains there for the succeeding winter and summer. When about a year old it measures about 4 or 5 inches. Very likely the next winter sees its first venture into the deeper offshore waters, and thereafter it will begin the inshore migration for the summer, and the offshore migration at the beginning of the winter. The adult ink-fish has thus a seasonal migration which is very common to the inhabitants of our seas. In this case, and this is also very usual, the summer migra-

tion is a spawning one, and the winter migration is one of dispersal and of shoaling, as the food is scarce or plentiful.

Protective Coloration.—Early in development the eyes receive a beautiful red pigment, and dots of red color appear in regular order on head and mantle. Appearing thus early, the pigment spots are at the time of hatching in a highly responsive condition, and are of the greatest value for the preservation of the individual. It is a simple arrangement. The red color is lodged in special cells, and these are either contracted or expanded, according to the surroundings, and all shades are possible, from very pale red to dark red. There are many predaceous fishes enemies of the squid at all stages, and the more the latter is like its surroundings the more is it likely not to be sighted. But in addition to the protection thus given and to the keen and efficient eyes with which it is provided, the squid, by virtue of its ink-sac, has the power of darting away in a cloud of sepia when attacked. It may be said to throw dust in the eyes of its would-be captor. It is a swift swimmer by admitting and expelling the water from the mantle cavity, and can crawl on the ten arms with which it is provided. But to attain a high state of organization, such as is found in the squid, where the molluscan shell has been got rid of or converted into a kind of backbone, where the eyes reach a most wonderful degree of development, where all the traditions have been set aside for the purpose of attaining speed, and the capacity for facing the world dependent upon agility rather than armor, it was essential that the creature should enjoy such protection as color could give it when in the resting state; but in this respect the sac of sepia, which it can employ so quickly and so effectively, is the most wonderful of all. That it needs all the protection it can get is shown by the fact that it is a favorite bait with line fishermen, and during the winter a basket of ink-fish frequently fetches a high price—bought by fishermen to be used for that purpose.—Newcastle Daily Chronicle.

METHODS OF INVESTIGATING MOVEMENTS OF EXPRESSION.*

By Prof. Sommer.

The idea that psychic processes involve movements of the brain, or of minute portions of the brain, is found clearly expressed in the psychology of the eighteenth century. The idea appears in dualistic or monostic, spiritualistic or materialistic form, according to individual conception and psychological education. Leibnitz, in particular, contributed greatly to the development of this doctrine with his idea of "pre-established harmony." Gradually it became recognized more and more fully that psychical processes have material counterparts in minute cerebral movements which are transmitted by the nerves to the muscular apparatus, and thus cause changes in external form in harmony with the mental phenomena. Evidently this idea was the basis upon which the science of physiognomy, subsequently developed chiefly by Darwin, was erected at the close of the eighteenth century. It should be noted that this conception supplied connecting links, which still hold, between psychology, physiology, and æsthetics.

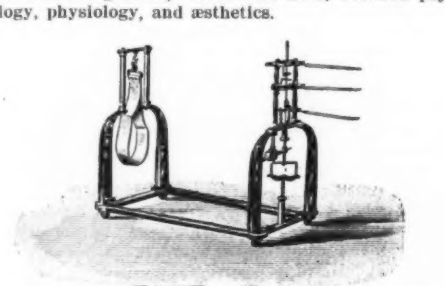


Fig. 1.—APPARATUS FOR INVESTIGATING FINGER MOVEMENTS IN THREE DIMENSIONS.

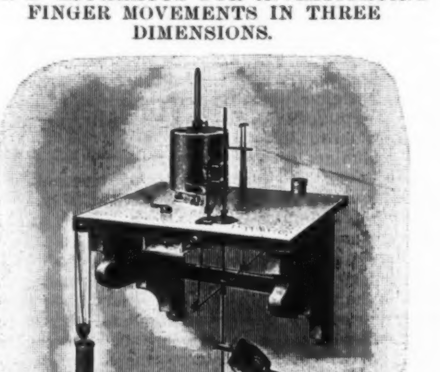


Fig. 2.—APPARATUS FOR INVESTIGATING MOVEMENTS OF THE FEET.

Starting from this physiological and historical point of departure, I attacked the subject experimentally. Ten years ago I exhibited to the International Congress of Psychologists in Munich an apparatus for the tri-dimensional analysis of finger movements of expression, which was suggested by these considerations (Fig. 1). In the present article I give a rough sketch of the various experimental studies which I have subsequently made in continuation of the investigation then begun.

The entire muscular system is controlled by psychophysical influences, which are expressed in attitudes and movements. It is a common error to regard a motionless position of a muscle as indicating a condition of rest, whereas it is the expression of a tension induced by the brain. This so-called tonic form of pression and is therefore liable to those errors which the new science of the psychology of testimony is revealing. Some of the phenomena, though seen, escape notice, some are exaggerated because the attention is almost confined to them, others are perceived dimly and are falsely reported even in the first statement. To these errors are added the changes subsequently undergone by remembered perceptions, and all the involuntary distortions of perception caused by associations, feelings, and interests. In short, there are

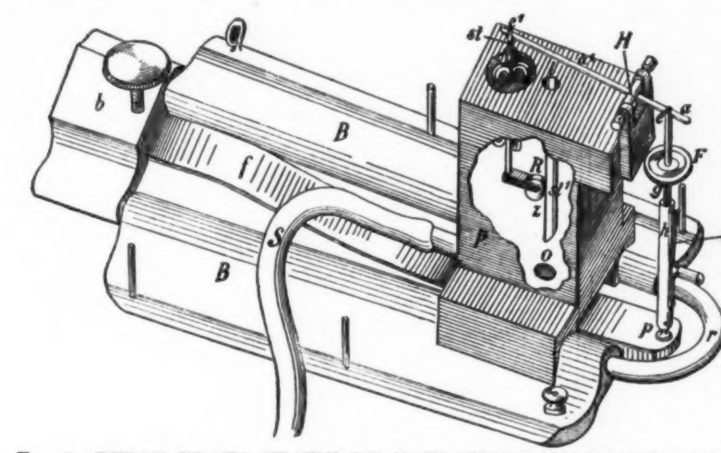


Fig. 5.—PULSE BEATS SHOWN BY VARIATIONS IN MUSICAL PITCH.

The wrist being held between the clamps *B B*, the button *p*, pressed on the artery by the spring *f*, transmits its motion through rods and levers, to the roller *R* which regulates the free length of the tongue *z*, of the reed *st*. Air is forced into the reed-chest through *O*.

the movements of expression, which is conditioned by muscular tension, and the locomotor movements, in which the limbs move about the joints, are of the highest importance.

This appears most clearly in the so-called "catatonic" forms of mental disease, which are characterized by stereotyped and often very peculiar attitudes and gestures. These, however, are not absolutely abnormal phenomena, but merely striking examples of the great significance of the movements of expression, and of their appearance in the two forms of locomotion and attitude. Essentially similar phenomena appear in the other forms of mental disease, though it should be added that, even in the present state of science, the particular form of disease may be clearly recognized, in many cases, by means of the characteristic peculiarities of the movements of expression, and this method of diagnosis will probably be greatly developed in the future. Hence many other well known diseases besides the "catatonic" ones furnish practical examples of the characteristic significance of the movements of expression.

The same process that furnishes diagnostic symptoms in disease plays a prominent part in normal life. This fact was known to the physiognomy of the eighteenth century.

Our task, then, is to observe and, if possible, to

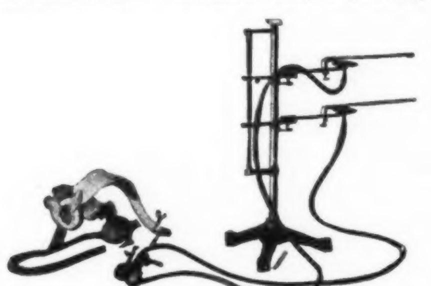


Fig. 3.—APPARATUS FOR INVESTIGATING MOVEMENTS OF MUSCLES OF THE FOREHEAD.

Fig. 4.—MOVEMENTS OF EXPRESSION SHOWN IN LIGHT AND COLOR EFFECTS.

represent objectively, the movements of expression in each muscular region, in order to measure and compare them and to apply them to the determination of mental states in both normal and diseased persons.

Various methods may be employed for this purpose. The oldest is the verbal descriptive method which at one time was used almost exclusively. It attempts to reproduce in words all the phenomena of facial expression and is therefore liable to those errors

many psychological reasons why this descriptive method appears untrustworthy. A further objection is that the hearer or reader is compelled to reverse the process and translate the description back into an image.

For these reasons attempts have long been made to supplement the verbal description by optical methods of representation, of which drawing was practically the only one available in Lavater's time, in the eighteenth century. In the nineteenth century it became possible to employ photography, together with various mechanical devices. A very great advance was made by the application of stereo-photography to the reproduction of physiognomical attitudes and gestures. A comparative study of simple and stereoscopic photographs of the same facial expression or bodily attitude will demonstrate the great improvement made in the realistic representation of psycho-physiological forms of expression by the introduction of stereoscopy. This constitutes a transition from representation in two dimensions to the representation in three dimensions which I have realized by mechanical methods of investigating the movements of expression. The optical method has been further improved by the employment of the kinematograph, which has made possible the study of physiognomical processes as well as states. Here the optical method passes into the investigation of the course of psycho-physiological movements, to which we owe so much, in both physiology and pathology.

A third method may be called mechanical copying. In practical criminology it has long been known that parts of the body, such as the finger tips, may readily be copied, for purposes of identification, by mechanical pressure upon smoked paper, wax, and other materials. This suggests the mechanical reproduction of other superficial phenomena, and especially of the folds of the skin produced by muscular contraction in the physiognomical region. Particularly well adapted to such reproduction are the furrows of the forehead, which are closely related to nerves and muscles of psycho-physiological function, as becomes plainly evident in certain forms of disease.

For the purpose of copying these lines I used a roller covered with smoked paper, which was moved rapidly over the forehead. After the attainment of the dexterity required to apply the roller lightly and without lateral motion or blurring, it is often possible to secure impressions of the furrows, the comparative study of which furnishes many characteristic symptoms of catatonia, melancholia, and other diseases. Often, however, the method fails, because we have to do with rapidly-changing forms of expression, which require a method of reproducing the progress of the movements. The method of mechanical copying appears to be susceptible to extension and systematic development.

The fourth method I call that of experimental neurology. It consists in determining, by tracing nerve tracts and by the electrical stimulation of single nerves and muscles, what parts of the physiological apparatus are involved in a complex group of movements of expression, as in laughing, weeping, anger, or astonishment. It is very important, here, to study the coordinated movements which, in certain forms of mental expression, are associated with the innervation of a group of muscles. In the physiognomical region complex relations are found to exist between the muscles of the eyes, forehead, and other parts of the face. I can only touch upon this extensive and interesting field of physiological correlation, which Darwin has opened, noting particularly the relation between human and animal movements of expression.

The fifth group of methods, with the development of which I have been much occupied, comprises meth-

* A paper read before the international congress of psychologists in Rome, April 29, 1905.

ods of physiological registration. As in stereoscopy, I have sought to represent the natural movements in all three dimensions. Turning my attention, first, to the voluntary muscles I succeeded, gradually, in constructing apparatus which registers unfailingly the smallest movements of the hands, feet, and muscles of the forehead for considerable periods, so that the progress of the phenomena can be studied (Figs. 1 2, 3).

Of great value are the methods of registering vocal movements which Rousselot, in particular, devised and Krueger, of Leipzig, is now developing, along the lines of my own investigation.

I have recently begun to translate the movements of the fingers, etc., into phenomena of light and color by means of the apparatus shown in Fig. 4, which was exhibited before the congress for experimental psychology in Giessen. It is also necessary to study the involuntary expression—movements of the blood vessels. To the usual cardiographic and sphygmographic methods of tracing heart beats and pulse beats I have sought to add a translation of the pulse into musical tones by the apparatus shown in Fig. 5, in which the pulse beats cause alternate lengthening and shortening of the vibrating portion of a reed, and thus produce an incessant change of pitch, by which the most minute movements of the artery are audibly expressed. Variations of cutaneous blood pressure induced by nervous action also play an important part in the psycho-physiology of the emotions. Hitherto the apparatus known as the plethysmograph has been chiefly employed in recording blood pressure and its indications have been regarded as correct expressions of the changes in the vascular system. This conclusion is not strictly warranted, owing to the frequent occurrence of involuntary muscular movements, which simulate vascular changes. The movements of the blood vessels must be distinguished from those of the muscles and studied apart. For this purpose I have used a capsule covered with a membrane and pressed upon the skin so as to make an air-tight junction. As the volume of the capsule varies in consequence of vascular movements, the displacement of the membrane affects a stream of gas, and consequently a gas-flame, the fluctuations of which correspond to the movements. In this way I hope to obtain more satisfactory results than those of the usual methods.

Respiration also plays an important part in the psycho-physiology of emotion. It might seem that the registration of respiratory movements, in physiology and clinical medicine, had already reached perfection, but a study of the effect of the emotions upon respiration shows that the mere registration of the movements of the chest will not suffice, as the characteristic phenomena are dependent on the relations between the movements of the chest and abdomen. The latter are chiefly due to the co-operation of the diaphragm, and when this is paralyzed by fear or other nervous influences, the type of respiration is entirely changed. It is necessary, therefore, to record the respiratory movements of the chest and diaphragm simultaneously, which can be done by an extension of methods now in use. Only in this duplex way can the psychophysical influence of the emotions upon respiration be correctly represented.

The recently-discovered electromotive effects form another group of movements of expression. In continuation of the investigations of Von Tarchanoff and Sticker I have shown, by improved methods, that the electric currents produced by laying the hands on metallically-connected electrodes are due, not solely to variations in the moisture of the skin, but partly to involuntary movements of expression which produce fluctuating pressures of the fingers on the electrodes. At all events, it is certain that in this way psychophysical processes, though not electrodynamic of themselves, may cause ultimate effects of electromotive character. In pursuing this line of investigation it has been shown that the statically-charged fingers exert, through electrical influence without physical contact, a mechanical effect upon strips of metal leaf, which react like levers to the approach of the fingers. By this investigation I think that I almost solved the problem of transmitting movements of expression to indicating apparatus without friction. That the avoidance of friction is the essential technical requirement of such apparatus and methods, will be conceded by every one who knows the difficulties which attend the application of mechanism to physiological research.

All these investigations agree in the fundamental principle of studying, impartially, the bodily phenomena, induced by nervous action, which accompany mental processes. In the course of them many new glimpses have been gained of the relation of cerebral processes to simple nervous reflexes, and of the phenomena of normal attitudes, fatigue, fear, attentiveness, etc., and it is now possible to present the results objectively in the form of movements.

DIAMONDS.*

By Sir William Crookes.

From the earliest times the diamond has fascinated mankind. It has been a perennial puzzle—one of the "riddles of the painful earth." It is recorded in Sprat's "History of the Royal Society" (1667) that among the questions sent by order of the society to Sir Philiberto Vernatti, resident in Batavia, was one inquiring "Whether diamonds grow again after three or four years in the same places where they have been digged out?" The answer sent back was: "Never, Or at least as the memory of man can attain to."

* Abstract of a lecture delivered before the South African meeting of the British Association for the Advancement of Science.

In a lecture "On Diamonds," more than forty years ago,* Prof. Maskelyne said: "The diamond is a substance which transcends all others in certain properties to which it is indebted for its usefulness in the arts and its beauty as an ornament. Thus, on the one hand it is the hardest substance found in nature or fashioned by art. Its reflecting power, and refractive energy, on the other hand, exceed those of all other colorless bodies, while it yields to none in the perfection of its pellucidity." He was constrained to add: "The formation of the diamond is an unsolved problem."

Of late years the subject has fascinated many men of science. The development of electricity, with the introduction of the electric furnace, has facilitated research, and I am justified in saying that if the diamond problem is not actually solved, there is every probability it shortly will be solved.

South Africa, as I will show in detail, is the favorite haunt of diamonds on this planet; it ranks with Australia and California as one of the three great gold-yielding regions. But the wealth of South Africa is not limited to gold and diamonds. It is also the illimitable home of coal—"the black diamond" of the universe. The province of Natal alone contains more coal than Britain ever owned before a single bucket had been raised; and the coal beds extend into the Orange River colony. Valuable iron ores exist also in large quantities.

In addition to these lavish natural riches the high grounds above Cape Town abound in medicinal health-giving waters. The districts where these springs occur are high lying, free from malaria, and admirably adapted for the restoration of invalids. It needs only some distinguished individual to set the fashion, some emperor, prince, or reigning beauty to take the baths and drink the waters, and the tide of tourists will surely carry prosperity to Aliwal North, Fraserburg, Cradock, and Fort Beaufort.

It is to the diamond industry I specially direct your attention to-night. I have studied diamonds scientifically for thirty years, and of the Kimberley mines I speak with the freshness of personal experience. In 1896, I spent nearly a month at Kimberley, when Mr. Gardner Williams, general manager of the De Beers Consolidated Mines, and the managers of neighboring mines, did their utmost to assist me in my inquiries and to aid me with valuable information. I had free access to all the workings, above and below ground, examined at leisure their stock and took extracts from their books. I had exceptional opportunities of studying the peculiar geological formation, and of noting facts connected with the birth of the precious stone which forms the subject of this evening's lecture.

Although my experiments are chiefly connected with the physical and chemical properties of diamonds, and with researches on the perplexities of their probable formation, it will be a kind of compensation for the dryness of some theoretical points, if with the help of a few photographs—taken on my former visit to South Africa—I bring before your eyes the general character of the mines and their surroundings.

The most famous diamond mines are Kimberley, De Beers, Dutoitspan, Bultfontein, and Wesselton. Kimberley is practically in the center of the present diamond-producing area. The mines are situated in latitude 28 deg. 43 min. south, and longitude 24 deg. 46 min. east. There are also river washings in the neighborhood of the Vaal River, where the work is conducted in somewhat primitive fashion. When I was at Klipdam, miners had congregated at a spot called "New Rush," where some good finds of diamonds had been reported. At one of the claims where work was proceeding vigorously I asked the proprietor to let me be present at the sorting out. He willingly consented, but no diamonds were found. On my expressing regret, he said he had not seen a diamond for a fortnight! But then he had picked out one worth £300, "and that," he said, "will pay for several weeks' wages of my boys." This is the kind of speculative gambling that goes on at the river diggings. The miner may toil fruitlessly for months, and then luckily come across a pocket of stones, swept there by some eddy, by which he will net thousands. Diamonds from the "river washings" are of all kinds, as if contributed by every mine in the neighborhood. They are much rolled and etched, and contain a fair proportion of stones of good quality, as if only the better and larger diamonds had survived the ordeal of knocking about. Besides these mines, there are in the Orange River colony—about 60 miles from the Kimberley diamond region—two others of some importance known as Jagersfontein and Koffyfontein, while about 20 miles west-northwest of Pretoria is situated the New Premier mine, now famous as the home of the wonderful "Cullinan" diamond.

KIMBERLEY.

The surface of the country round Kimberley is covered with a ferruginous red, adhesive, sandy soil, which makes traffic heavy. Below the red soil is a basalt, much decomposed and highly ferruginous, from 20 to 90 feet thick, and lower still from 200 to 250 feet of black slaty shale containing carbon and iron pyrites. Then deeper a bed of conglomerate about 10 feet thick, and below the conglomerate about 400 feet of a hard compact rock of an olive color, called "melaphyre,"† or olivine diabase. Below the melaphyre is a hard quartzite about 400 feet thick. The strata are almost horizontal, dipping slightly to the north; in places they are distorted and broken through by protruding dykes of trap. There is no water nearer than the Vaal River, about 14 miles away; formerly the miners were dependent on rain water and a few springs and pools. Now, however, a constant and abundant supply of excellent water is served to the town. Good brick houses, with gardens and orchards, have sprung up on all sides.

* Chemical News, vol. i, p. 208.

† "Melaphyre. A waiting room for rocks, till called for.

THE PIPES.

The five diamond mines are all contained in a precious circle 3½ miles in diameter. They are irregular shaped round or oval pipes, extending vertically downward to unknown depths, retaining about the same diameter throughout. They are considered to be volcanic necks, filled from below with a heterogeneous mixture of fragments of surrounding rocks, and of older rocks such as granite, mingled and cemented with a bluish colored hard clayey mass, in which famous blue clay the imbedded diamonds are hidden.

The areas of the mines are:

Kimberley	33 acres.
De Beers	22 "
Dutoitspan	45 "
Bultfontein	36 "

Before the discovery of the mines there was nothing in the superficial appearance of the ground to indicate the priceless treasures below. Since the filling of the volcanic ducts with diamantiferous ground, denudation has planed the surface; and the upper parts of the craters and other ordinary signs of volcanic activity being smoothed away, the superficial and ubiquitous red sand has covered and disguised the whole surface. The Kimberley mine seems to have presented a slight elevation above the surrounding flat country, while the sites of other mines were level or even slightly depressed.

Other diamantiferous pipes in the neighborhood are small and do not contain stones in payable quantities. Hoards of diamonds may await the lucky discoverer, but where there are no surface signs, and the pipe itself is hidden under 10 or 20 feet of recent deposits, prospecting is a matter of sheer speculation. Hitherto accident has been the chief factor in the discovery of diamond mines.

How the great pipes were originally formed is hard to say. They were certainly not burst through in the ordinary manner of volcanic eruption, since the surrounding and inclosing walls show no signs of igneous action, and are not shattered or broken up even when touching the "blue ground." It is pretty certain these pipes were filled from below after they were pierced, and the diamonds were formed at some previous time and mixed with a mud volcano, together with all kinds of *débris* eroded from the rocks through which it erupted, forming a geological "plum pudding." The direction of flow is seen in the upturned edges of some of the strata of shale in the walls, although I was unable to see any upturning in most parts of the walls of the De Beers mine at great depths.

The breccia filling the mines, usually called "blue ground," is a collection of fragments of shale, and of various eruptive rocks, bowlders, and crystals of many kinds of minerals. Indeed, a more wildly heterogeneous mixture can hardly be found anywhere else on this globe. The Kimberley mines for the first 70 or 80 feet are filled with so-called "yellow ground," and below that with "blue ground." This superposed yellow on blue is common to all the mines. The blue is the aboriginal ground, and owes its color chiefly to the presence of lower oxides of iron. When atmospheric influences have access to the iron it becomes peroxidized, and the ground assumes a yellow color. The thickness of yellow earth in the mines is therefore a measure of the depth of penetration of air and moisture. The color does not affect the yield of diamonds. The ground mass is soapy to the touch, and friable, especially after exposure to weather. Besides diamonds, more than eighty species of minerals have been recognized in the blue ground, the most common being magnetite, ilmenite, garnet, bright green ferriferous enstatite (bronzite), a hornblendic mineral closely resembling smaragdite, calc-spar, vermiculite, diallage, jeffreysite, mica, kyanite, augite, peridot, iron pyrites, wollastonite, vaalite, zircon, chrome iron, rutile, corundum, apatite, olivine, sahlite, chromite, pseudobrookite, perofskite, biotite, and quartz.

The blue ground does not show any signs of igneous action; the fragments in the breccia are not fused at the edges. The eruptive force was probably steam or water-gas, acting under great pressure but at no high temperature.

There are many such pipes in the immediate neighborhood of Kimberley. It may be that each volcanic pipe is the vent for its own special laboratory—a laboratory buried at vastly greater depths than we have yet reached—where the temperature is comparable with that of the electric furnace, where the pressure is fiercer than in our puny laboratories and the melting point higher, where no oxygen is present, and where masses of liquid carbon have taken centuries, perhaps thousands of years, to cool to the solidifying point. The chemist arduously manufactures infinitesimal diamonds, valueless as ornamental gems; but Nature, with unlimited temperature, inconceivable pressure, and gigantic material, to say nothing of measureless time and appalling energy, produces without stint the dazzling, radiant, beautiful, coveted crystals that I am enabled to show you to-night.

This hypothesis of the origin of diamonds is in many ways corroborated.

The ash left after burning a diamond invariably contains iron as its chief constituent; and the most

common colors of diamonds, when not perfectly pellucid, show various shades of brown and yellow, from the palest "off color" to almost black. They are also green, blue, pink, yellow, and orange. These variations give support to the theory advanced by Moissan that the diamond has separated from molten iron—a theory of which I shall say more presently—and also explain how it happens that stones from different mines, and even from different parts of the same mine, differ from each other. Further confirmation is given by the fact that the country round Kimberley is remarkable for its ferruginous character, and iron-saturated soil is popularly regarded as one of the indications of the near presence of diamonds. Along with carbon, molten iron dissolves other bodies which possess tinctorial powers. One batch of iron might contain an impurity coloring the stones blue, another lot would tend toward the formation of pink stones, another of green, and so on. Cobalt, nickel, chromium, and manganese, all metals present in the blue ground, would produce these colors.

An hypothesis, however, is of little value if it only elucidates half a problem. Let us see how far we can follow out the ferric hypothesis to explain the volcanic pipes. In the first place we must remember these so-called volcanic vents are admittedly not filled with the eruptive rocks, scoriaceous fragments, etc., constituting the ordinary contents of volcanic ducts.

A selection of thin sections of some of these rocks and minerals, mounted as microscopic objects and viewed by polarized light, are not only of interest to the geologist, but are objects of great beauty.

The appearance of shale and fragments of other rocks testify that the *mélange* has suffered no great heat in its present condition, and that it has been erupted from great depths by the agency of water vapor or some similar gas. How is this to be explained?

You will recollect that I start with the reasonable supposition that at a sufficient depth* there were masses of molten iron at great pressure and high temperature, holding carbon in solution, ready to crystallize out on cooling. Far back in time the cooling from above caused cracks in superjacent strata through which water† found its way. On reaching the incandescent iron, the water would be converted into gas, and this gas would rapidly disintegrate and erode the channels through which it passed, grooving a passage more and more vertical in the necessity to find the quickest vent to the surface. But steam in the presence of molten or even red-hot iron liberates large volumes of hydrogen gas, together with less quantities of hydrocarbons‡ of all kinds—liquid, gaseous, and solid. Erosion commenced by steam would be continued by the other gases; it would be easy for pipes, large as any found in South Africa, to be scored out in this manner.

Sir Andrew Noble has shown that when the screw stopper of his steel cylinders in which gunpowder explodes under pressure is not absolutely perfect, gas escapes with a rush so overpowering as to score a wide channel in the metal. Some of these stoppers and vents are on the table. To illustrate my argument Sir Andrew Noble has been kind enough to try a special experiment. Through a cylinder of granite is drilled a hole 0.2 inch diameter the size of a small vent. This is made the stopper of an explosion chamber, in which a quantity of cordite is fired, the gases escaping through the granite vent. The pressure is about 1,500 atmospheres, and the whole time of escape is less than half a second. Notice the erosion produced by the escaping gases and by the heat of friction; these forces have scored out a channel more than half an inch diameter and melted the granite along their course. If steel and granite are thus vulnerable at comparatively moderate gaseous pressure, it is easy to imagine the destructive upburst of hydrogen and water-gas grooving for itself a channel in the diabase and quartzite, tearing fragments from resisting rocks, covering the country with débris, and finally, at the subsidence of the great rush, filling the self-made pipe with a water-borne magma in which rocks, minerals, iron oxide, shale, petroleum, and diamonds are violently churned in a veritable witch's cauldron! As the heat abated the water vapor would gradually give place to hot water, which forced through the magma would change some of the mineral fragments into the existing forms of to-day.

Each outbreak would form a dome-shaped hill; the eroding agency of water and ice would plane these eminences until all traces of the original pipes were lost.

Actions such as I have described need not have taken place simultaneously. As there must have been many molten masses of iron with variable contents of carbon, different kinds of coloring matter, solidifying with varying degrees of rapidity, and coming in contact with water at intervals throughout long periods of geological time—so must there have been many outbursts and upheavals, giving rise to pipes containing diamonds. And these diamonds, by sparseness of distribution, crystalline character, difference of tint, purity of color, varying hardness, brittleness, and state of tension, have the story of their origin impressed upon them, engraved by natural forces—a story which future generations of scientific men may be able to interpret with greater precision than is possible to-day.

* A pressure of fifteen tons on the square inch would exist not many miles beneath the surface of the earth.

† There are abundant signs that a considerable portion of this part of Africa was once under water, and a fresh-water shell has been found in apparently undisturbed blue ground at Kimberley.

‡ The water sunk in wells close to the Kimberley mine is sometimes impregnated with paraffin, and Sir H. Roscoe extracted a solid hydrocarbon from the "blue ground."

The contents of the several pipes are not absolutely identical. The diamonds from each pipe differ in character, showing that the upflow was not simultaneous from one large reservoir below but the result of several independent eruptions. Even in the same mine there are visible traces of more than one eruption.

The blue ground varies in its yield of diamonds in different mines.

According to tables furnished by the De Beers Company, the yield of the De Beers and Kimberley mines has declined as the depth increases. At the same time the value of the stones has risen, and diamonds are more expensive to-day than at any previous time.

Year.	Number of carats* per load.†	Value per carat. s.	d.
1889	1.283	19	8.75
1890	1.15	32	6.75
1891	0.99	29	6
1892	0.92	25	6
1893	1.05	29	0.6
1894	0.89	24	5.2
1895	0.85	25	6
1896	0.91	26	9.4
1897	0.92	26	10.6
1898	0.80	26	6.2
1899	0.71	29	7.2
1900	0.67	35	10.2
1901	0.76	39	7
1902	0.76	46	5.7
1903	0.61	48	6.3
1904	0.54	48	11.8

The diamonds from each mine have a distinctive character, and so uniform are the characteristics that an experienced buyer can tell at once the locality of any particular parcel of stones. De Beers and Kimberley mines are distinguished by the yield of large yellowish crystals with curved edges; Dutoitspan yields mainly colored stones, while Bultfontein—half a mile off—produces small white octahedral crystals, occasionally speckled and flawed, but rarely colored. The diamonds from the Wesselton mine are characterized by the large number of perfect octahedra of pure water among them. The diamonds from the Leicester mine have a frosted, etched appearance; they are white, the crystallization irregular ("cross-grained"), and they are hard and expensive to cut. Stones from Jagersfontein, in the Orange River colony, display great purity of color and brilliancy and they have the so-called "steely" luster characteristic of old Indian gems.

Let me cite a description of a visit to Kimberley in 1872, by Mr. Paterson, who gives a graphic picture of the early days:

"The New Rush Diggings (as the Kimberley mine was first called) are all going forward in an oval space inclosed around by the trap dyke, of which the larger diameter is about 1,000 feet, while the shorter is not more than 700 feet in length. Here all the claims of 31 feet square each are marked out with roadways about 12 feet in width, occurring every 60 feet. Upon these roadways, beside a short pole fixed into the roadway, sits the owner of the claim with watchful eye upon the Kaffir diggers below, who fill, and hoist by means of a pulley fixed to the pole above, bucketful after bucketful of the picked marl stuff in which the diamonds occur."

Soon came the difficulty how to continue working the host of separate claims without infringements. A system of rope haulage was then adopted. This mode of haulage continued in vogue during the whole of 1873, and if the appearance of the mine was less picturesque than when roadways existed, at least by moonlight it was a weird and beautiful sight.

But the mine was now threatened in two other quarters. The removal of the blue ground undermined the support from the walls of the pipe, and frequent falls of reef occurred, not only burying valuable claims but endangering the lives of workers below. Moreover, as the workings deepened, water made its appearance, necessitating pumping.

It soon became evident that open workings were doomed, and by degrees was devised the present system of underground working.

During this time of perplexity, individual miners who might have managed one or two claims near the surface could not continue work in the face of harassing difficulties and heavy expenses. Thus the claims gradually changed hands until the mine became the property first of a comparatively small number of capitalists, then of a smaller number of limited liability companies, until the whole of the mines have practically become the property of the De Beers Consolidated Mines, Limited.

UNDERGROUND WORKINGS.

In the face of constant developments I can only describe the system in use at the time of my own visit—1896. Shafts are sunk in the solid rock at a sufficient distance from the pipe to be safe against reef movements in the open mine. In 1903, the rock shafts in the De Beers and Kimberley mines reached depths of 2,076 and 2,599 feet respectively. Tunnels are driven from these shafts at different levels, about 120 feet apart, to cross the mine from west to east. These tunnels are connected by two other tunnels running north and south, one near the west side of the mine and one midway between it and the east margin of the mine. From the east and west tunnels, offsets are driven to the surrounding rock. When near the rock, the offsets widen into galleries, these in turn being stoped on the sides until they meet, and upward until they break through the blue ground. The fallen reef with which the upper part of the mine is filled sinks and partially fills the open space. The workmen then stand on the fallen reef and drill the blue ground overhead, and as the roof is blasted back the *débris* follows. When stoping between two tunnels the blue is stoped up to the *débris* about midway between the two tunnels. The upper levels are worked back in advance of the lower levels, and the works assume the shape of irregular terraces. The main levels are from 90 to 120 feet apart, with intermediate levels every 30 feet. Hoisting is done from only one level at a time through the same shaft. By this ingenious method every portion of blue ground is excavated and raised to the surface, the rubbish on the top gradually sinking and taking its place.

* According to Gardner Williams the South African carat is equivalent to 3.174 grains. In Latimer Clark's "Dictionary of Metric and Other Useful Measures," the diamond carat is given as equal to 3.1683 grains = 0.2053 gramme = 4 diamond grains. One diamond grain = 0.792 troy grain. 151.5 diamond carats = 1 ounce troy.

Webster's "International Dictionary" gives the diamond carat as equal to 3 1/5 troy grains.

The "Oxford English Dictionary" says the carat was originally 1/144 of an ounce, or 3 1/3 grains, but now equal to about 3 1/5 grains, though varying slightly with time and place.

The "Century Dictionary" says the diamond carat is equal to about 3 1/6 troy grains, and adds that in 1877 the weight of the carat was fixed by a syndicate of London, Paris, and [illegible] jewelers at 205 milligrammes. This would make the carat eq[illegible] troy grains.

† A load weighs about 1600 pounds.

The scene below ground in the labyrinth of galleries is bewildering in its complexity, and very unlike the popular notion of a diamond mine. All below is dirt, mud, grime; half-naked men, dark as mahogany, lithe as athletes, dripping with perspiration, are seen in every direction, hammering, picking, shoveling, wheeling the trucks to and fro, keeping up a weird chant which rises in force and rhythm when a greater task calls for excessive muscular strain. The whole scene is more suggestive of a coal mine than a diamond mine, and all this mighty organization, this strenuous expenditure of energy, this costly machinery, this ceaseless toil of skilled and black labor, goes on day and night, just to win a few stones wherewith to deck my lady's finger! All to gratify the vanity of woman! "And," interposed a lady who heard this remark, "the depravity of man!"

With gems like diamonds, where fabulous riches are concentrated into so small a bulk, it is not surprising that precautions against robbery are elaborate. The illicit diamond buying (I. D. B.) laws are very stringent, and the searching, rendered easy by the "compounding" of the natives, is of the most drastic character. Formerly the favorite method of stealing diamonds was to swallow them, but when suspected, the personal inconveniences—in which certain powerful drugs took part—rendered this ingenious mode of stealing unpopular. It is, in fact, very difficult for a native employe to steal diamonds; were he to succeed, it would be almost impossible to dispose of them, as a potential buyer would prefer to secure the safe reward for detecting a theft rather than run the serious risk of doing convict work on the Cape Town breakwater for a couple of years. I heard of a native who, secreting a diamond worth several hundreds of pounds, after trying unsuccessfully to sell it, handed it back to the manager of his compound, glad to get the 6d. a carat to which he was entitled. Before the passing of the "Diamond Trade Act," the value of stolen diamonds reached nearly one million sterling per annum.

As a rule the better class of natives—the Zulus, Matabeles, Basutos, Bechuanas—when well treated, are honest and loyal. An amusing instance was told me of the devotion of a Zulu. He had been superintending a gang of natives on a small claim at the river washings near Klipdam. The claim yielded few stones, and the owner—my informant—sold the claim, handing over the plant and small staff, our friend the Zulu continuing to look after the business when the new man took possession. In the course of a few months the purchaser became dissatisfied with his bargain, not a single diamond having turned up since the transfer. Soon after this the Zulu came to his old master in a mysterious manner, and laying a handful of diamonds on the table, said: "There, Baas, are your diamonds; I was not going to let the new man have any of them!"

DEPOSITING FLOORS.

Owing to the refractory character of blue ground fresh from the mines, it has to be exposed to atmospheric influences before it will pulverize under the action of water and mechanical treatment. It is brought to the surface and spread on the floors. Soon the heat of the sun and moisture produce a wonderful effect. Bowlders, hard as ordinary sandstone when fresh from the mine, commence to crumble. At this stage the treatment of the diamonds assumes more the nature of farming than mining. To assist pulverization by exposing the larger pieces to atmospheric influences, the ground is frequently harrowed and occasionally watered. The length of time necessary for crumbling the ground preparatory to washing, depends on the season of the year and the amount of rain. The longer the ground remains exposed the better it is for washing. When the process is complete the softened friable blue clay is again loaded into trucks and taken to the washing machinery, where it is agitated with water and forced through a series of revolving cylinders perforated with holes about an inch in diameter; incorrigible lumps that will not pass the cylinders are again either subjected to the weathering process or passed between crushing rollers.

If a miner sees a diamond in a truck or in any of the blue ground in the mine, he has orders to secure it, and when he comes to the surface report it to the

manager of the compound. If a white laborer, he is then credited with 3s. a carat, and if a black 6d. a carat. For a diamond found on the depositing floors about half these sums are paid.

(To be continued.)

REPAIRING BROKEN NEGATIVES.

Mr. O. H. Boye, writing on this subject in a recent issue of the Monthly Review of the P. A. of California, says:

Where a negative is divided into but two or three pieces, stripping the film from the broken parts and floating it on to another glass is the method that should preferably be adopted. Many formulas for this process have appeared in print, and work with varying degrees of success. Hydrofluoric acid is a messy solution at best, and requires very careful treatment, or the film is easily torn. The formalin method is to be preferred as the safest process, allowing as it does a greater latitude in the handling. The formula recommended below is thoroughly reliable, and also has the merit of being simple to work.

A stock solution of 10 per cent of caustic soda should be made up. The formalin recommended is the 40 per cent solution supplied to the trade:

Solution A: Caustic soda (10 per cent solution) ½ ounce, formalin solution ¼ ounce, water 5 ounces.

Solution B: Hydrochloric acid 1 drachm, water 8 ounces.

The negative to be treated should first be thoroughly cleaned from all traces of varnish. Before doing so, however, take a blunt knife and a straight-edge and scratch a line through the film to the glass around the four sides of the negative close to the edges. This will give a clean edge for the solutions to act upon, and also facilitate matters considerably in stripping. The pieces of the negative to be stripped can be supported upon a sheet of plain glass and attached thereto with rubber cement, shoemaker's wax, or any medium of a similar nature that will not dissolve in the solutions. This is for convenience in handling, and not absolutely necessary, as each piece can be stripped separately if preferred. After soaking in the water for about a half-hour, immerse the plate in solution A for five minutes, rinse slightly, and then transfer to solution B for a similar period. Rinse well after this bath and place on the table, face up, ready for stripping. Dampen a clean sheet of writing paper large enough to lap over the plate all around. Lay this on the film and cover with a blotter. Squeegee the paper into contact with the film by rubbing with your hand on the back of blotter. Take some blunt-pointed instrument or a knife and start a corner of the film by gently lifting it up with the paper. It will come away readily enough; but watch carefully for places that are inclined to stick. Touching them lightly with the blunt point will assist in making them yield.

A gelatine-coated plate previously prepared should be in readiness. The formula for this substratum is the same used for the carbon process. A clean glass plate immersed in this solution while still warm and left to drain and dry is what is required. Rinse the surface of this plate well with water and lay flat on table. The film can now be lowered into position on its new support and rubbed into contact under a blotter. Remove the paper, and should any bubbles remain between film and glass they can be worked out by dabbing them lightly with the finger toward the edge of the plate. The remaining pieces can now be transferred in the same manner, but in adjusting the pieces together it is important that an overlap of about 1-16 inch be allowed for shrinkage in drying. While drying these places where the film overlaps, it should be occasionally dabbed or pressed into contact in order that it adhere tightly to the glass at these points. After drying, should the overlap be too great, scraping off the surplus film with the etching tool will result in securing a perfect match.

Negatives that are simply cracked and not broken through the film are quickly transferred by this method. This process is also used for the reversing of negatives for the carbon process where a single transfer print is desired. Where an enlargement of a negative is wanted, say, of a cabinet to an 8 by 10, the stripping process is the quickest solution of the problem. The hardening bath is omitted, and plates are simply treated by immersing in the hydrochloric acid alone. The film expands considerably after leaving its support, more than doubling its former size. Should this expansion prove too great, immersing it in alcohol will cause it to contract to the point wanted, or almost back to its original size.

AN AUTOMOBILE TESTING LABORATORY.

By the Paris Correspondent of Scientific American.

The extensive establishment in Paris known as the Conservatoire des Arts et Metiers (National Institute of Arts and Trades) has recently fitted up a number of extensive testing laboratories in which experiments may be made upon different kinds of apparatus and instruments, including tests of strength of materials. The new laboratories, under the direction of M. Pérot, contain a number of instruments and apparatus which present a novel character. Among these we may describe the new method which is employed for testing automobiles. Accurate information can thus be obtained as to the number of horse-power which a given car is capable of furnishing, also other valuable data which are difficult to obtain without a complete installation of this kind. The apparatus, as it is now installed in the testing room, will be observed in one of the illustrations, while the sectional view shows its general principles. The two driving wheels of the automobile are each made to rest upon a large revolving drum which lies below the level of the floor. Most of the mechanism, including the two drums, lies below the surface and is contained in a cement-lined pit. The latter is provided with a series of removable covers lying flush with the floor. The drums, seen at A and B, measure some 6 feet in diameter and 2 feet wide. They are of cast iron, with an outer rolling surface of oak planking. The drums are mounted upon a long shaft, C D, made in two pieces, and assembled by bolts. They can be adjusted forward or back so as to bring the centers under the different automobile wheels, and the tops of the drums lie about flush with the floor. Three heavy bearings, C F G, also adjustable, support the shaft at the ends and the middle. At H is a Prony brake whose friction pressure can be regulated

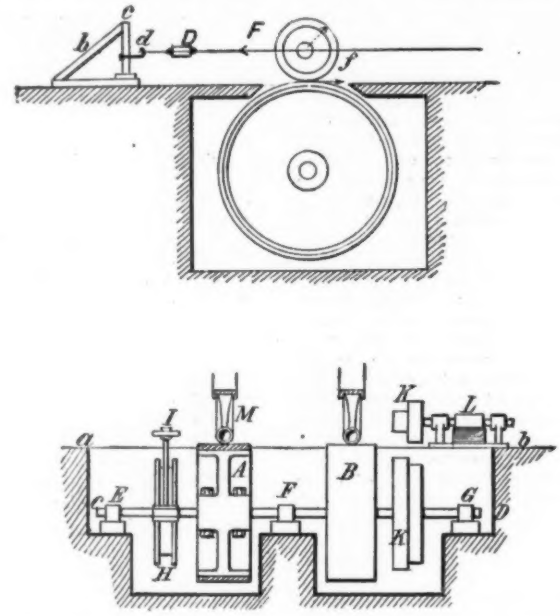
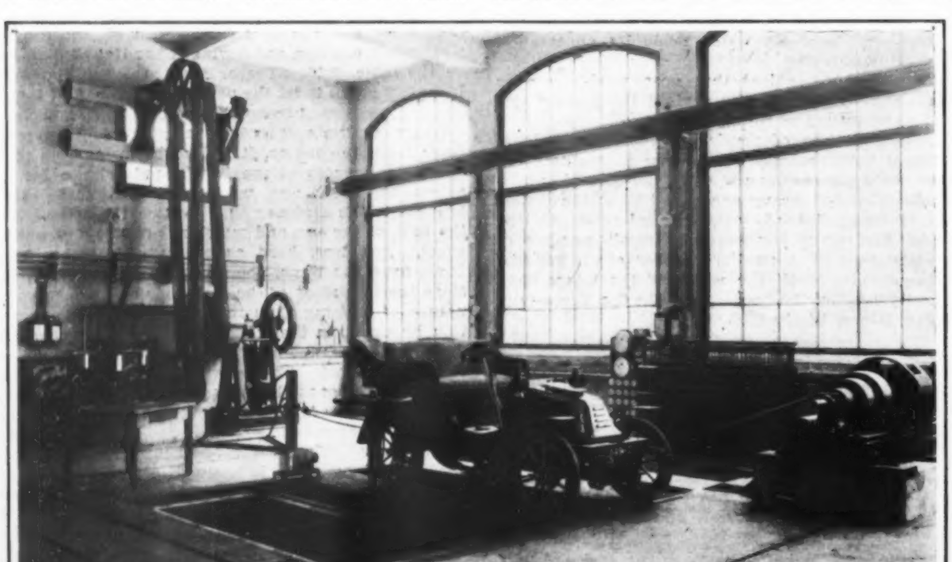


DIAGRAM OF DRUMS DRIVEN FROM THE WHEELS OF AN AUTOMOBILE WHILE TESTING THE MACHINE.

from above by means of the hand-wheel, I, mounted on a column. To enable the brake to absorb a large amount of energy without heating up, it is provided with a water-cooling device by which it can take some 50 horse-power while still keeping within the limits.

One of the noteworthy features of the device is the use of the dynamo, L, which will also be noticed at the right of the photograph. It is a Gramme dynamo of 30 horse-power, making from 500 to 1,000 revolutions per minute. A set of double pulleys placed upon the dynamo and the shaft of the drums allows of adjusting the speed. The dynamo is adapted to run either as a generator or a motor, as the case may be. When working as a motor it causes the drums to revolve, while in the case where the drums are operated by the wheels of the automobile, the dynamo serves as an electric brake, acting then as a generator and furnishing current. The latter current is absorbed by a set of resistance coils mounted in open frames, which will be observed in the rear, together with the different measuring instruments for the dynamo circuit. In the other case, where the dynamo acts as a motor, the resistances also serve for starting, in the usual way. It is found that the dynamo, when thus mounted, acts as a very efficient brake, and besides it can be regulated evenly and gradually by means of the resistance coils, which are subdivided in small units and can be thrown on progressively. Another method of regulating the braking action of the dynamo is to vary the current which is sent through the field coils, and the latter is furnished from a separate circuit.

In testing a given automobile by the apparatus, we wish to find the power developed at the periphery of the wheel, or else the power which is transmitted from the motor to the driving axle of the car. To carry out the test, the driving wheels, M M, of the car are placed upon the drums, A B, and adjusted so that the center of the wheel is exactly in the vertical line with the center of the drum. This is brought about by displacing the drums upon the shaft. We then see that the pneumatics of the two wheels are inflated at the same pressure and that the radii of the two driving wheels are equal when under the usual load of the car. The upper diagram shows the working positions. The car is attached to a fixed support, d, by a wire cable, through a pressure device, D, which forms part of an hydraulic registering dynamometer. The latter is installed on a table to one side of the pit and is connected with D by a thin copper tubing. The speed of the car wheel is taken by a Richard tachymeter which is attached to the driving shaft by a pulley. The wheels of the automobile cause the large drums to revolve and the latter are then braked either by the Prony brake, L, or the dynamo, as before observed. In each case the energy can be accurately measured. If need be the two brakes can be made to work together, and in this case as high as 80 horse-power can be absorbed. A necessary point in making the test is to place the point of attachment at the car and the point d on exactly the same horizontal line. This is best carried out by using a water level formed of two cylinders with a connecting rubber tube. When the whole system is running normally, it is in equilibrium under the action of the forces F and f, which are equal and in the opposite sense. The work per minute in kilogramme-meters is given by the formula $T = f\,2\pi\,rn$, in which n is the number of revolutions per minute of the car wheels (taken by the speed counter), r the radius of the driving wheel in meters, f (or F) the tractive effort in kilogramme-meters measured on the



A WELL-EQUIPPED TESTING LABORATORY FOR AUTOMOBILES.

hydraulic dynamometer. The latter can be read within 1 or 2 per cent. The power is obtained from the formula $\frac{T}{75 \times 60} = \frac{f \times 2\pi rn}{75 \times 60}$, whence $Frn = \frac{2\pi}{75 \times 60}$ whence $P = Fnr \frac{2}{75 \times 60} = \frac{14\ Fnr}{10{,}000}$.

It is indispensable in making the test to have the driving shaft exactly centered over the shaft of the drums. This is carried out by two plumb lines which are hung from the ceiling. The lines pass by the center of the shaft, *C D*, one at each end of the latter and at each side of the automobile. By sighting the two wires and working a hand wheel which displaces the bearings of the shaft, *C D*, we can bring the shaft exactly in line.

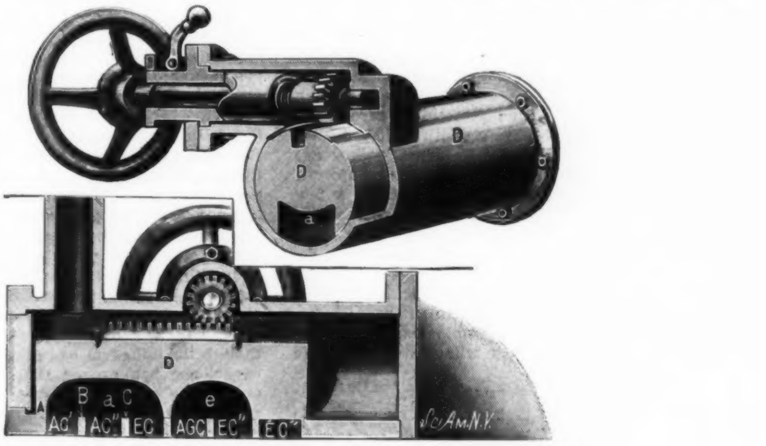


FIG. 1.—TRANSVERSE AND LONGITUDINAL SECTIONS OF THE DISTRIBUTER.

A NEW FOUR-CYLINDER PORTABLE STEAM ENGINE.

ALTHOUGH it is true that the piston steam engine is seriously threatened by the turbine, it is quite rare at present to witness the advent of absolutely new types of piston engines distinguished by very marked characteristics from the general arrangement that has been adopted for many years. So we have thought that it would be of interest to describe a new motor that may be easily applied to automobile carriages and boats—a motor having four cylinders which make it possible to run it as a compound engine in two different manners or as a triple expansion engine. We must say at once that some experiments have been made for the purpose of ascertaining whether the coefficient of uniformity of the cycle is affected according as the admission occurs in one, two, or three cylinders. The range between the two extreme methods of operation is but 13-100, which is of slight consequence in practice, and the more so in that the mass of the apparatus actuated by the motor tends to make the running uniform without the use of a flywheel. The engine has no dead center, and it always gives a positive impulse except when the admission takes place in two cylinders, and only then during a short space of time, at the end of the stroke and before and at the beginning of the return stroke. Nothing is easier than to start with the third method of operation, that is to say, with admission into the three cylinders.

This engine, which is of the Lefevre system, is constructed by the firm of Fryer & Co., of Rouen. If we examine the stationary type of it (the others differing only in certain details), we shall see that it comprises four simple acting cylinders placed crosswise and in the same plane, at right angles with the rotary axis of the shaft. The four corresponding pistons are connected directly with a single crank pin by means of connecting rods whose ends form segments that are assembled around the pin by two collars. Of course, the axes of the four cylinders form angles of 90 deg. with each other. Three only of the cylinders have the same diameter (the cylinders *C*, *C'*, *C''*), that is to say, the top cylinder and the two lateral ones, while the lower cylinder, *G C*, has a diameter double that of the others. All are provided with a cylindrical distributing slide valve, to which motion is imparted by one eccentric in common, assembled by a lug and a bolt on the prolongation of the crank shaft. In the illustration may be perceived a handwheel that controls a rack mechanism which operates the very original distributer devised by Mr. Lefevre. To this distributer may be given three distinct positions, each of which naturally corresponds to a different method of operation of the motor. It is simply a cylindrical slide valve provided with two cavities, *a* and *e*, of unequal length, which put in communication, in different manners, the ports of the cylinder channels. According to the position of this valve, the steam coming from the boiler is admitted into one, two, or three cylinders, and expanded in the others respectively, so that the power developed varies in consequence.

In order to make the operation of this interesting device understood, we must necessarily enter into completer details. The steam coming from the boiler enters the box of the distributer, which constantly communicates with the port, *A C*, and permits the cylindrical slide valve, *T*, to admit the said steam into the cylinder, *C*. The steam, after doing its work, is led through the upper channel of the valve, *T*, and through the channel, *E C* (shown in Fig. 1), into the cavity, *a*, of the distributer, whence it passes through the channels *A C'* and *A C''*, and, entering the two cylinders, *C'* and *C''*, is expanded therein when their respective slide valves open the admission. On the other hand, through a channel formed in the frame, the slide valve of the cylinder, *C'*, always allows of the escape of the steam into the conduit, *A G C*, of admission to the large cylinder, so that the steam does not pass through the distributer in order to finish its expansion. On the contrary, that of the cylinder, *C''*, is directed through the escapement port, *E C''*, and through the cavity, *e*, of the distributer, into the conduit, *A G C*. Finally, all the steam of the large cylinder escapes through the interior of its cylindrical slide valve into the base of the engine, and thence flows into the open air or into the condenser, if a condenser is used. The position of the distributer, as described above, causes the engine to be run with triple expansion, which is adapted for small loads and naturally affords a better utilization of the steam. If, now, we displace the distributer in such a way that its edge, *A*, shall coincide with partition, *B*, of the chamber, we shall have the first position for compounding. The steam, in fact, not only enters the cylinder, *C*, but also, and at the proper moment, the cylinder, *C''*, through the uncovered port, *A C''*. After it has operated under full pressure, it expands in the third cylinder, *C'''*, and in the fourth and large cylinder, *G C*, in passing through *a*, which puts the exhaust chamber, *E C*, in connection with the ports, *A C''* and *A G C*. As in the preceding case, the large cylinder communicates, through a special conduit, with the exhaust chamber of *C'*. It is evident that, with this method of operation, we obtain a higher power, but not so satisfactory a utilization of the steam.

Let us suppose, in the third place, that we bring the edge, *A*, of the distributer upon the partition, *C*. The live steam will then enter the three small cylinders without the intervention of the distributer for the first, and, for the two others, through the ports, *A C'* and *A C''*, which are uncovered. Upon making its exit from these three cylinders, the steam enters the large cylinder through the channel, *A G C*, which always

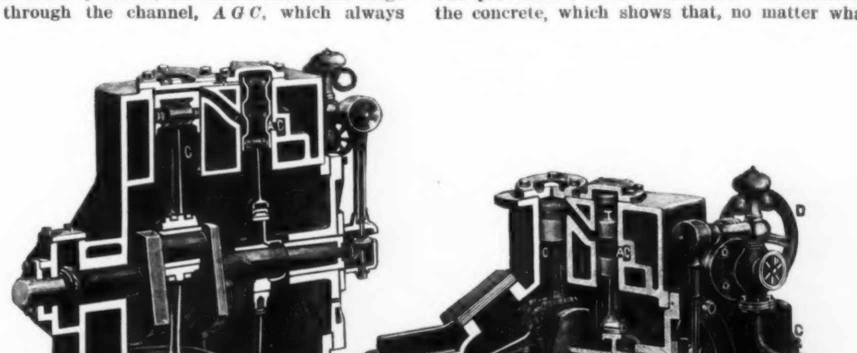


FIG. 2.—TRANSVERSE SECTION OF THE LEFEVRE MOTOR.

communicates directly with *C'*, and which the chamber, *a*, puts in connection with the ports, *E C* and *E C''*. As for the chamber, *e*, and the port, *E' C'*, they merely assure a supplementary exhaust. We have thus, then, the second compound combination, in which the power of the motor is maximum.

It will be seen that we were right in saying that the power of this engine is very remarkable, since, without any modification of the steam pressure or the rotary velocity, it can be run triple expansion with single introduction, or double expansion with double introduction, or, again, double expansion and triple introduction, which gives a power triple that obtained with the first method of running. Each of such methods of running is submitted to the regulating action of a balanced butterfly valve, placed upon the steam conduit in front of the regulator and actuated by a high-speed governor, controlled by bevel gears and an intermediate shaft. The valve passes from the position of maximum opening to complete closing for a three per cent deviation in speed.

We may add (what an examination of the figures will show, however) that this engine is particularly compact. All its parts are protected from dust and shocks by metallic casings. The lubricating is done automatically by means of two pumps actuated by a worm gear secured to the crank shaft. In a 50 horsepower with triple expansion (corresponding to 75 in the first compound running and to 125 in the second), the diameter of the small cylinders is 5.25 inches, and that of the large ones, 10.75, with a stroke of 6.25. The number of revolutions is normally 675. These powers are obtained without condensation. It is evident that such an engine is capable of rendering great service under many circumstances and especially in automobiling. In the latter case it may be simply modified by the addition of an ingenious change of speed that we have not the space to describe. This new motor is so much the more interesting in that its consumption of fuel is relatively small.—Translated from La Nature for the SCIENTIFIC AMERICAN SUPPLEMENT.

REINFORCED CONCRETE—SOME OF ITS PRINCIPLES, WITH PRACTICAL ILLUSTRATIONS.

By WALTER LORING WEBB.

ECONOMICS.

THE justification of the use of reinforced concrete is usually based on some one or all of three conditions. First, under some circumstances it is actually more economical than any other rational method of construction. Secondly, there are cases where it is almost the only practicable method of construction. Thirdly, there are cases where it is simply preferable. It is not very easy to demonstrate the economy of this method except by comparative cost in individual cases, but an approach to a systematic comparison may be made as follows: A cubic foot of steel weighs 490 pounds. Assume as an average price that it can be bought and placed for 4.5 cents per pound. The steel will therefore cost $22.05 per cubic foot. On the basis that concrete may be placed for $6 per cubic yard, the concrete will cost 22 cents per cubic foot, which is 1 per cent of the cost of the steel. Therefore, on this basis, if it is necessary to use as reinforcement an amount of steel whose volume is in excess of 1 per cent of the additional concrete which would do the same work, there is no economy in the reinforcement, even though the reinforcement is justified on account of the other considerations. Assuming 500 pounds per square inch as the working compressive strength of concrete, and 16,000 pounds as the permissible stress in steel, it requires 3.125 per cent of steel to furnish the same compressive stress as concrete. On the above basis of cost, the compression is evidently obtained much more cheaply in concrete than in steel—in fact, at less than one-third of the cost. On the other hand, even if we allow 50 pounds per square inch tension in the concrete and 16,000 pounds in the steel, it only requires 0.31 per cent of steel to furnish the same strength as the concrete, which shows that, no matter what may be the variation in the comparative price of concrete and steel, steel always furnishes tension at a far cheaper price than concrete, on the above basis, at less than one-third of the cost. The practical meaning of this is, on the one hand, that a beam composed wholly of concrete is usually inadvisable, since its low tensile strength makes it uneconomical, if not actually impracticable, for it may be readily shown that, beyond a comparatively short span, a concrete beam will not

support its own weight. On the other hand, on account of the cheaper compressive stress furnished by concrete, an all-steel beam is not so economical as a beam in which the concrete furnishes the compressive stress and the steel furnishes the tensile stress. This statement has been very frequently verified when comparing the cost of the construction of floors designed by using steel I-beams supporting a fireproof concrete floor, and that of a concrete floor having a similar floor slab but making the beams as T-beams of reinforced concrete.

Another instance of the actual economy of this method of construction is furnished by a recent design for a retaining wall. The wall was to be 14 feet in height and the design was for a skeleton reinforced concrete construction. It has a base plate of the requisite width, so that the center of pressure of the base will be properly located. Buttresses which run back into the embankment at proper intervals are connected with the base plate, while the face of the wall between the buttresses has only such thickness as is required to withstand the bursting pressure developed between each pair of buttresses. The whole structure is reinforced with steel so as to take up all the tensile stress which may be developed in any part of the wall. The cross-section of this wall has an average value of 25.44 square feet, which is the equivalent of 25.44 cubic feet per linear foot of wall. A wall of rubble masonry was designed by well-known railroad engineers for this same location. This wall had a cross-section of 80.45 square feet. On the basis of 25 cents per cubic foot, or \$6.75 per cubic yard, each linear foot of the rubble wall would cost \$20.12. Of course, the unit price of the concrete wall is considerably higher, but its volume is but little over 30 per cent of the volume of the stone wall. In this particular case an estimate for this wall at the rate of 40 cents per cubic foot as measured in place was obtained from a reliable contractor, the estimate including the steel and all other items of construction except mere excavation, which was not included in the first estimate. The concrete wall would therefore cost \$10.16 per linear foot, which is practically *one-half* of that of the stone wall. Many other illustrations could be given where reinforced concrete construction is the cheapest that gives a permanent structure.

As an instance of the second class of structures, viz., those in which reinforced concrete is almost the only practicable method of construction, the following case is given. It was required to construct a retaining wall with a height of 36 feet above the rails of a sunken track where the right-of-way was absolutely limited to a width that gave 10 feet from the right-of-way line to the clearance line for the tracks. The wall was designed to have its base 42 feet below the top. Of course, 10 feet is too small a base for a 42-foot retaining wall. The only possible solution appeared to be some provision by which the toe of the wall could extend underneath the track. Of course, such a construction in stone masonry or even in plain concrete would be an utter impossibility, since it would inevitably break at the angle of the base. A structure of concrete and steel in which the transverse stress at the lower angle of the wall is resisted by the horizontal steel bars in the base, with the very considerable pressure of the earth on the base plate behind the face wall, accomplished all that is desired. The resultant line of pressure is within the middle third of the base, while the maximum intensity of pressure on the subsoil was computed to be about 6,400 pounds per square foot. As the subsoil is a very firm gravel this pressure is a perfectly safe one, but if it had been found that the soil was less reliable it would have been a comparatively simple matter to enlarge the foundation as much as necessary. Of course, the conditions of this problem were very peculiar and unusual, and it illustrates what can be done under such circumstances.

Since the above was written the Engineering News, in its issue of March 9, page 262, published an interesting account of a wall constructed by the Great Northern Railway Company at Seattle, Wash. The wall is over 40 feet from base to top at the highest point, varying from this maximum to nearly zero. The economy of the design in comparison with a wall in plain concrete was computed. There was shown to be a saving of 20.4 per cent for a wall 10 feet high and of 45 per cent for a wall 40 feet high. But in this case there was no question of limitation of the base of the footing behind the face of the wall, and therefore no necessity of extending the toe of the wall under the tracks.

The third class of structures, viz., those in which reinforced concrete is simply preferable, may be illustrated by the very simple case of fireproof floors. One of the compensations of the Baltimore fire was its demonstration of the fact that a concrete floor when properly made approaches the ideal by being more nearly absolutely fireproof than any other flooring material. It has been frequently stated that since concrete is formed by the crystallization of a compound containing water, it only requires heat to drive off the water and render the whole structure worthless from a structural standpoint. In one sense this is true, provided the heat is sufficient; but the Baltimore fire proved that even with the very excessive degree of heat which was developed during that fire, the effect of such heat on a concrete floor was merely to calcine the lower layer of concrete to a depth varying from ½ inch to 1 inch. After such calcination occurred, this layer of heat-resisting material proved to be such a thorough protection that the concrete above it was uninjured, and considering that the concrete lying above the axis of the reinforcement is the only portion which is considered in calculating the strength, and also considering that an inch or two of concrete is always placed below the steel reinforcement, even the destruction of an inch of concrete on the lower side of a concrete slab will not impair its structural strength. After such a fire, the injured material may be scraped off, so far as it is loose, and another protecting layer, which is only put on for protection and not for structural strength, can be added.

Another very satisfactory use of reinforced concrete is in the construction of roof slabs for fireproof buildings. The author has recently constructed a factory and boiler house entirely of concrete. Even the side walls were built of hollow concrete blocks. The floors are of concrete, the roof slab of concrete, and even the stairs are made of concrete. The boiler house has a roof with a clear span of 30 feet formed by placing a 4-inch slab on concrete beams stretching across the span of 30 feet. The beams have a depth of 13½ inches under the slab and a width of 7¾ inches. They are spaced 6 feet 2½ inches apart. The slab is reinforced by ½-inch bars spaced 16 inches apart. Only a few weeks after the roof was in place and before the concrete had attained anything like its full strength a very unexpected and unintentional test of the roof occurred. A steel stack was being erected, the stack being put into place by means of a derrick. The derrick broke, a large gin-pole was broken in three pieces, the stack crumpled up, and the whole mass of wreckage fell on this roof. No injury whatsoever was done to the roof.

PLAIN BARS VS. "FORMED" BARS.

The term "formed" bar is here used as a generic term to denote any style of bar which is not prismatic. A prismatic bar depends on adhesion or friction for the union of the concrete and the steel. The "formed" bar has shoulders, lugs, twists, swellings, or irregularities which not only more or less effectively prevent the loosening of the adhesion by varying the planes of adhesion and thus varying the direction of the forces which will most probably loosen the adhesion, but they even call into play the shearing strength of the concrete before the rod can be pulled through it, even if the adhesion be destroyed.

Much experimenting has been done to determine the adhesion of concrete to steel. It has been found that when the steel is clean concrete will adhere to it with an adhesion which is equal to the strength of the bar when the length is approximately 12 to 20 diameters. Unfortunately the adhesion, as determined by such tests made shortly after the specimens were formed, has been shown to lack permanency. This may be due to one of three causes. First, the adhesion may be loosened by vibration in the structure—such a vibration as will occur in a railroad bridge or in a factory employing very heavy machinery. Second, some cases in which the concrete was found to have loosened were explained on the ground that water which had soaked through the concrete had made some chemical change in the concrete immediately adjoining the steel which was sufficient to loosen the adhesion. Third, it is reasonable to say that when the structure is stressed to its full load (and especially if it should accidentally be stressed beyond its designed load) the stretching of the bar must be accompanied by a proportionate reduction in its cross-section. Evidently the concrete will be unable to contract so as to retain its contact with the steel, and therefore the steel must separate from the concrete. Probably the number of applications of a given load will have a marked effect on this, and it would be found, after applying a load a very great number of times (say 1,000,000), that loosening might take place even though no evidence of such loosening would occur by the application of that same load a few times. An instance of this sort occurred in a building erected in St. Louis about ten years ago. A 6-inch concrete slab carrying a heavy floor-load was supported by steel I-beams spaced about 8 feet apart. The concrete was reinforced by 1¼-inch by ¼-inch bars or straps which were hooked over the I-beams and dropped down on a curve toward the bottom of the concrete slab in the middle of the span. The floor safely carried a heavy floor-load for about eight years. Then several panels began to yield. The floor sagged 1½ inches in the middle, which on an 8-foot span gave a very unsightly and unsafe appearance to the floor. One or two panels caused so much anxiety that they were knocked out entirely. It was at once observed that the concrete peeled off the bars, and it was plainly evident that the adhesion between the bars and the concrete had been destroyed, the load then being carried by the hog-chain action of the straps. It should be noted in this case that for about eight years the floor did its work and carried a very heavy load, thus proving that the ultimate failure was not due merely to poor workmanship, but was due to the fact that the adhesion of the bars was not permanent. This fact has been recognized by the city of Philadelphia in recent specifications for reinforced concrete bridges, in which it is required that "the steel rods embedded in the concrete shall be of some approved shape, especially formed for reinforcing concrete so as to secure an interlocking bond between the steel and the concrete."

It has, however, been very definitely demonstrated that a mechanical bond furnishes a far stronger union between the steel and the concrete than can possibly be furnished by plain bars. About two years ago Prof. Spofford made a series of tests in the laboratories of the Massachusetts Institute of Technology to determine this very point. A large number of specimens, of which forty-five were reported in the published tests, were made by molding prisms of concrete. The prisms varied in cross-section from 6 inches by 6 inches to 10 inches by 10 inches, and in length from 12 inches to 50 inches. The rods included plain round, plain square, and plain straps, also Ransome, Thacher, and Johnson bars of sizes varying from ½ inch to 1¼ inches, and with a length somewhat greater than the length of the prisms. They were placed in the axes of the prisms during molding. The load upon the bearing end of the concrete block was distributed by the interposition of a sheet of ½-inch felt between the concrete and an annular steel ring resting upon the platform of the machine. In all cases the rod projected a short distance at the upper end of the block, the pull being downward at the lower end, and this projecting end was carefully watched in order to detect the first evidence of slipping. Although it was intended that the size of the prism should be sufficient in all cases to develop the full strength of the bar, it was found that the largest bars were too large even for the 10-inch by 10-inch prisms in which they were inserted. It was invariably found that the formed bars required a far greater stress in the rod in pounds per square inch of net section than the plain bars. Incidentally it may be mentioned that the Johnson corrugated bar invariably required a pull from two to three times as great per square inch of net section as a plain bar. These results therefore show: first, that if the stress in a reinforced concrete structure for any reason exceeds very greatly the designed loading and approaches the elastic limit of the steel, a formed bar is far safer than a plain bar, even though the adhesion has not been destroyed. Secondly, experience has proved that the adhesion may be destroyed by any one of three causes, and that it is unreliable for any great length of time, no matter what its tested strength may prove to be on new specimens. Thirdly, that a Johnson corrugated bar will have as great a hold in the concrete as a plain bar at its best, even though the adhesion of the Johnson bar had been utterly destroyed by vibration or any other cause. Incidentally it may be added that the writer has been told of some tests which were made on this line in which the bars were deliberately oiled in order to determine their hold in the concrete under such a condition. It was found that there was practically no adhesion and that the bars could be drawn out of the concrete with an insignificant force. This practically means that if the reinforcing steel should be accidentally smeared with oil or grease the adhesion would be vitiated to some extent, and since the mutual action of the concrete and the steel is absolutely dependent on the intimate union of the concrete and steel at all points, the strength of the structure might be vitiated to perhaps a dangerous extent by some such carelessness during construction. In the tests made at the Massachusetts Institute of Technology all the bars were sandblasted, which of course made the conditions the most favorable for the plain bars. Of course, it likewise made it most favorable for all kinds of bars. But oil on a formed bar would merely reduce its adhesion and not destroy the union between the concrete and the steel. On the other hand, oil on a plain bar will render it utterly useless and endanger the strength of the structure. It is also true that if the bars have been allowed to get rusty to any great extent the adhesion is affected.

EFFECT OF ELASTIC LIMIT OF THE STEEL.

There is still much controversy over the effect of the elastic limit on the mechanics of reinforced concrete structures. The writer has no intention of entering into a theoretical argument on this point, but will merely point out the fact that there are some phases of this detail which are beyond discussion. It may readily be seen that when the steel is strained beyond its elastic limit the union between the concrete and the steel is unquestionably destroyed. If that union depends on mere adhesion, it is certainly destroyed absolutely. If the bars are specially formed, there will still remain a very great resistance, although the structure is unquestionably very seriously weakened, if not actually unsafe. Therefore if we can safely raise the elastic limit, we raise by just that amount the safety of the structure. A great deal of work has been designed using steel which has an ultimate strength of say 64,000 pounds per square inch and using a working stress of 16,000 pounds, and the designer thinks that he has a factor of safety of 4. If the ultimate strength is 64,000 pounds, the elastic limit is probably about one-half of this, or 32,000 pounds. Therefore the real factor of safety is only 2. In other words, if the loading should ever by any mischance be increased to more than double the normal loading, the structure would actually fail, since the elastic limit would have been passed, and, as above shown, the union between the concrete and steel would have been destroyed.

There is a radical distinction between a steel-concrete structure and an all-steel bridge, for example. If a steel bridge be overloaded to such an extent that the unit stress is raised to a little beyond the elastic limit, the structure will not necessarily fail. When the stress is removed, the bridge will not entirely recover its former position, the cross-section of some tension pieces will be slightly reduced, but the unit strength is possibly greater, and the bridge can still do its normal work, although the factor of safety may have been slightly reduced. But when the steel in a steel-concrete structure has been stretched beyond the elastic limit, the steel and concrete cannot return to the same relative positions they previously had. The union is unquestionably destroyed. Under such a condition the formed bar is certainly safer than a plain bar, but a combination of formed bar and a high elastic limit is far better. Several years ago bridge engineers thought they could effect economy by employing high carbon steel in the construction of bridges. Then they found

that, owing largely to punching and the irregular stresses produced in plates and structural shapes, the high carbon steel was unreliable, and now a return has been made to the softer steel. But when it is considered that there is no question of punching the steel used for steel reinforcement, and that the stresses in the steel are almost exclusively tensile, the ability of the high carbon steel to safely withstand them cannot be successfully attacked, provided the steel is not actually brittle. The shearing stresses which may occur in the steel bars are always so far within the shearing strength of the steel that they need not be considered. The Johnson corrugated bars are usually rolled from the same grade of steel as is employed in making railroad rails. There are few metal structures which are subjected to such excessive and irregular stresses as railroad rails. From the standpoint of impact and change of stress there are few metal structures which are so tried. Nevertheless a broken rail is exceedingly rare, considering the hundreds of thousands of miles which are in use. Therefore it would seem like an over-refinement and a needless sacrifice of strength to limit one's self to a grade of steel which has a virtual limit of 30,000 or 32,000 pounds per square inch when it is so easily possible to obtain a material which is thoroughly reliable for its purpose, against which no failure can be reported, and which has a virtual ultimate (by which I mean the elastic) limit of 55,000 to 65,000 pounds per square inch. Such a bar can be as safely used with twice the working strain as would be used with soft steel, or, if it is used with the same working strain, the factor of safety against a possible overloading is practically doubled. Of course, I would not advocate for a moment using a working stress of 25,000 to 30,000 pounds per square inch with the higher grade steel. In fact, Mr. Johnson usually employs 16,000 pounds per square inch working stress with his bars, in spite of the elastic limit of 55,000 to 65,000 pounds and an ultimate strength of 95,000 pounds. But I do wish to express very strongly the opinion that using a working stress of 16,000 pounds for soft steel in steel-concrete work is not only bad designing—it is recklessness.

It will not do to say that overloads will never occur. A cyclone may produce wind stresses in a building which are several times the stresses provided for, and it is a common experience to see a warehouse floor loaded up with a floor-load which is four or five times that for which it was designed.

STRESSES IN REINFORCED CONCRETE.

It is natural that some engineers should have considerable skepticism regarding the accuracy of theoretical computations of the strength of reinforced concrete structures. The theory is excessively complex, and, secondly, concrete is by some considered a very unreliable material. There is, therefore, considerable value in the tests which were made recently by Prof. Howe at the Rose Polytechnic Institute, at Terre Haute, Ind. These were tests of full-size concrete beams which were purposely made so as to represent commercial practice as closely as possible. Atlas cement, bank sand, crushed rock, and corrugated steel bars were purchased in the open market. The mixing was done by a local contractor of experience with his own gang of men in the manner he ordinarily employed. Instead of using "standard quartz sand," which is so frequently used in test work and which gives results which cannot be compared with commercial practice, he used a sand which, "while containing some 'dirt' in the form of yellow clay, was a fair representation of bank sand used in Terre Haute." The beams varied in length from 12 feet to 19 feet 6 inches. They had a uniform width of 12 inches, but their depth varied from 5 inches to 21 inches. It is difficult to apply a uniformly distributed load to a full-size beam and avoid a tendency to arching action of the load itself, which vitiates the results obtained. A concentrated load in the center also tends to produce a crushing of the beam, which may vitiate the calculations of its transverse strength. The method employed in these tests was to apply two equal concentrated loads, which are symmetrical with respect to the center of the beam, through knife-edges in rolling seats, which thereby produced a constant bending moment between the points of application of the load (excepting the variable moment produced by the weight of the beam). Usually the maximum moment actually developed was somewhat in excess of the theoretical moment as determined by the Johnson formula, probably on account of the fact that the Johnson formula uses 2,000 pounds per square inch as the ultimate strength of that grade of concrete and 50,000 pounds per square inch as the elastic limit of the steel (which is in reality the point of failure in steel concrete work), whereas the strength of the concrete was probably somewhat in excess of this, and the steel used actually showed an elastic limit of about 60,000 pounds per square inch. The vertical deflections were read directly from a scale on the side of the beam at the center by means of a silk thread fastened opposite the knife-edges of the end stirrup. Measurements were made to determine the position of the neutral axis for various loadings and the variation of its position for partial loadings. It was very definitely shown that at the commencement of the loading the neutral axis was below the center of the beam. Theory would indicate that for a light loading the neutral axis would be at the center of gravity of an inverted T-section, the sides of the T being formed by extending the concrete at the base of the beam by an amount proportional to the relative moduli of elasticity of steel and concrete, but it is found that, as the loads increase in magnitude, the axis moves upward very rapidly until cracks commence to appear on the bottom of the beam; then the axis remains approximately in the same position as long as the concrete does not show signs of failure in compression, as indicated by the drop of the scale beam. The special point to which I wish to call your attention in these tests is that in all the eighteen tests there were but six cases in which the actual maximum moment was less than the theoretical moment. Ordinarily the variation did not exceed 3 per cent. Such an agreement between theoretical formulæ and the actual breaking loads of full-sized commercially made beams is not only very gratifying, but is sufficiently close to inspire confidence in the method of the calculations. The method of calculating the strength of simple beams reinforced with steel is practically much simplified by the use of tables and diagrams.

EXPANSION JOINTS IN REINFORCED CONCRETE.

Another very important feature of this method of construction is the solution which it gives to the problem of expansion joints. It does so by cutting the Gordian knot and omitting expansion joints altogether. This may be safely done on the same general principle as is involved in the practice of street railway companies in using perfectly tight rail joints. In the case of the rails the changes of temperature do take place, and they result in severe tensile stress in cold weather and compressive stress in warm weather, but it is easily demonstrable that for such ranges of temperature as will occur the stresses are not unsafe and the rails can safely endure them. Precisely the same principle is involved in reinforced concrete walls. It is demonstrable that if 1/300 of the cross-section of the wall consists of steel *properly distributed*, all tendency to contract during cold weather will be resisted by the steel, and it is thus made possible to make concrete structures a mile long, if desired, without using any expansion joints. Experience in these structures has demonstrated that masses of concrete so long that they would inevitably have been badly ruptured by temperature contraction if they had been made of plain concrete, have successfully withstood all ranges of temperature without any cracking. In fact, the insertion of steel in structures merely for the purpose of withstanding this temperature cracking is not only justifiable, but a wise plan, even though the steel was not depended on to resist any other structural stress. This may explain an element of the design of some of these structures where bars are inserted in places where they are apparently unnecessary for withstanding structural stress. They are inserted as binders to prevent any possibility of the concrete cracking on account of temperature stresses.

In order to have some more definite figures regarding this, I wrote to the engineer of the St. Louis Expanded Metal Fireproofing Company for some explicit examples. An extract from his letter is as follows:

"The rear wall of the Harvard stadium is 1,400 feet long, built in the form of a U, and the same contains but one crack at one of the points of tangency, which may have been due to some improper workmanship at this point, perhaps. This job has passed through two severe winters, and my report on the condition of the same comes direct from Prof. L. J. Johnson, the man who had the work in charge.

"There is a retaining wall illustrated in our new catalogue which has passed through one winter and contains no crack. We built a wall in the city here, exposed on both sides to the weather, which is also 300 feet long and contains no crack. It is not that the metal absolutely prevents cracks, but if the metal does not slip in the concrete, the cracks will be very fine and close together, and these will be so small that in the case of the corrugated bar, at any rate, they would not be able to penetrate to the bar."

This is another illustration of the value of a "formed" bar over a plain bar. It is quite possible that temperature changes are one of the most potent causes of the loosening of the adhesion. Corrugations, and especially those which present a square shoulder against any tendency of the bar to move in the concrete, make such an intimate union between the concrete and the steel that temperature changes cannot affect them provided the cross-section of the steel is sufficient to resist the temperature stresses.

STEEL-CONCRETE TANKS.

The relative value of steel and concrete in mere tension has already been referred to. An example of this is found in the mechanics of large circular tanks, especially such as are used for gas-holders, when constructed of plain concrete. The principal stress on such a tank when designed to hold water is merely a bursting hydraulic pressure. When this has been sufficiently provided for, all other stresses, such as wind stresses, will be amply taken care of by the cross-section adopted. The working tension usually allowed for concrete does not exceed 50 pounds per square inch, whereas we readily employ 16,000 pounds per square inch for steel. This means that 0.31 per cent of steel will accomplish the same work and be even more reliable than the concrete. It means that the tension is provided for at one-third of the cost of an equal strength in concrete. But, on the other hand, a steel-concrete tank is found to be even cheaper as well as infinitely more durable than a plain steel tank. It is not enough in the case of a plain steel tank to provide just enough steel to withstand the bursting pressure. A very thin steel plate might have a sufficient area of steel to withstand the bursting pressure, but it would utterly collapse in the first wind storm. A steel tank likewise requires constant care and expense for painting and other forms of maintenance, and in spite of all care it is short-lived. On the other hand, a steel-concrete tank when properly made will endure indefinitely, and the cost of maintenance should be absolutely zero. In a steel-concrete tank the concrete not only effectively prevents the corrosion of the steel, but it furnishes the required stiffness and compressive strength (the steel bars taking up the tensile stress), and will permit the amount of concrete to be reduced to a figure which makes it cheaper than a proper design in plain concrete.

PROTECTION OF STEEL FROM RUSTING BY CONCRETE.

Unprotected steel rusts quite rapidly, especially when it is exposed in damp places, and since concrete is more or less porous, so that water may penetrate throughout a concrete structure, it is frequently assumed that even the imbedded steel will rust out. Although it is true that the modern system of reinforced concrete is a matter of the last few years, and therefore there has not been time to determine many of the results which will only appear after many years, there have fortunately been many occasions when the power of concrete to protect iron from rusting has been amply demonstrated. William Sooy-Smith, M. Am. Soc. C. E., reports a small piece of iron set in mortar taken from the base of the obelisk now in New York city which was bright and free from rust after 3,300 years. He also tells of the moving of a bed of concrete at a lighthouse in the Straits of Mackinac, twenty years after it was laid ten feet below the water surface. In this case driftbolts imbedded in the concrete were found to be free from rust. Many tests have been made in which it has been attempted to substitute for long periods of time a corresponding intensity of corrosive action, and although the results of such tests are not conclusive proof, yet they all point to the same conclusion, viz., that if concrete is mixed very wet so as to make it very dense, and if the steel is covered to a depth of an inch or more, there is absolutely no evidence of rusting, unless the steel is exceptionally foul when it is placed in the concrete. There has been considerable controversy over the possible effect of the fine hair cracks which frequently appear in the bottom of a concrete beam even when it is loaded within its designed loading, but the eminent chemist and cement expert, Spencer B. Newberry, has declared unequivocally that there is no danger that such cracks would result in corrosion of the steel under them. He points out the fact that the immediate effect, even when such a crack began to open, would be a slight chemical change, and the formation of a carbonate at the bottom of the crack which would effectively protect the steel from any corrosion.—Journal of American Society Civil Engineers.

WOOL GREASE FOR WATERPROOFING CLOTHES AND FABRICS.

Wool grease or suint is obtained as a by-product in spinning mills from the wash water of raw wool. The water submitted to the process of extracting the grease is also freed from potash and fatty acids, which latter are generally employed for the production of illuminating gas of good quality. The fine fatty coating constituting the fat of sheep's wool is known to preserve the skin of the animals in good condition and, above all, to render them capable of resisting any climatic conditions. The human body has also been found to be provided with a similar substance possessing the same qualities. Many endeavors have been made to utilize these properties of wool fat in industry. Thus a medicinal pomade, the well-known lanolin, has been prepared for years from the purified and naturalized wool grease from which the fatty acids and soaps have been removed. Berthier succeeded in rendering clothes impervious by means of lanolin, he having conceived this idea from the fact that the dress of the Arabs, woven from wool from which the fat has not been extracted, is also impermeable. He immersed the fabrics in a wool-grease solution or sprayed them with it, then allowing to dry. The garments thus prepared were found to be more permeable to air and exhalations than ordinary stuffs, in a soaked condition. The goods became wet only on the surface, and absorbed little water. Even repeated washing with soap does not impair the imperviousness of the fabrics treated with the lanolin. Owing to the simplicity of the process, says the Technische Woche, anybody may make use of it, employing neutral wool fat. Berthier has furthermore succeeded in transferring these qualities of wool grease to the leather used for shoes. A still purer product called agnolin was produced by Cordier by washing and distilling lanolin, which he successfully applied to keep the human skin in a healthy condition. Agnolin presents the advantage of not turning rancid, since it is not saponified even by alkalies. It is readily absorbed by the skin, has an antiseptic action, and prevents the appearance of bacteria. Since all these virtues of wool grease have become firmly established, efforts are constantly made to discover new uses. Various patents have been taken out recently on greases, soaps, and wax produced from it. Through all these discoveries a new field has been opened for the spinning mills to dispose of their by-products, which were for a long time considered almost worthless.

The smuts of wheat, oats, rye, barley, etc., form a class of diseases which have in past ages caused and still continue to cause immense loss. Pathologists have been more successful in overcoming this class of diseases. Where formerly from 20 to 40 per cent of the cereal crops were annually destroyed, now, by a simple and cheap treatment of the seed before planting, using formaldehyde, hot water, or copper sulphate, the loss may be reduced to less than 1 per cent.

ELECTRIC LIGHTING FOR AMATEURS.

It is now possible for any one to procure small incandescent lamps from the Edison Lamp Company, and from most dealers in electrical goods. The prices run as follows: ½, 1, 2, 3, 4, and 6 candle lamps, one dollar each. These little lamps can be operated quite successfully by means of easily constructed batteries. It is, of course, a little troublesome, and the expense of the electric light produced in this way is somewhat greater than other lights, but amateurs can derive a

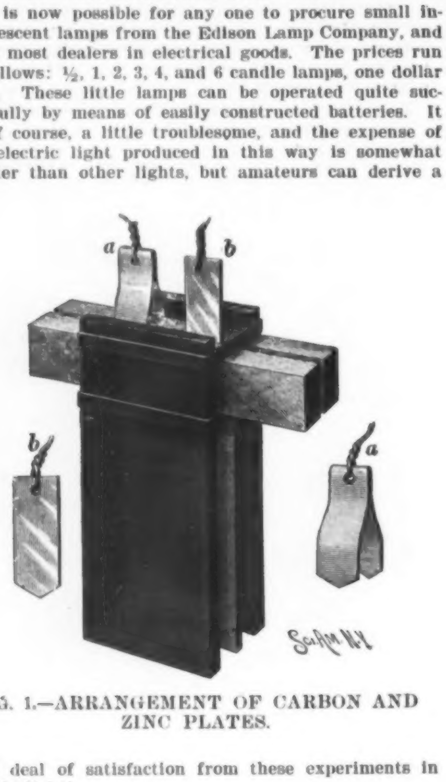


Fig. 1.—ARRANGEMENT OF CARBON AND ZINC PLATES.

great deal of satisfaction from these experiments in electric lighting.

The battery may be made at home, from materials that may be purchased from the manufacturers of the lamps or from any dealer in electrical supplies. Each cell of battery consists of two plates of carbon 2 inches wide, 4½ inches long, and ⅛ inch thick, one zinc plate 2 inches wide, 4 inches long, and ⅛ inch thick, two strips of wood ½ inch wide, ¼ inch thick, and 4 inches long, two strong rubber bands, and an ordinary tumbler.

The zinc is amalgamated by dipping it in dilute sulphuric acid (acid one part, water twelve parts), then sprinkling on a few small drops of mercury, rubbing it about with a swab formed of a piece of cotton cloth tied around the end of a stick. Every portion of the surface of the zinc should be covered with mercury. If the amalgamation is perfect, it need not be repeated.

The carbon plates before use should each be heated at one end and saturated with paraffine for a distance of 1¼ inch from the upper end (and no more) to prevent the solution from ascending the plate by capillarity. This is accomplished by heating the end of the plate over a lamp and applying a piece of paraffine or a paraffine candle until it is filled. No free paraffine should be allowed to remain on the surface of the carbon, as it will interfere with making a good electrical connection with the plate.

The zinc plate is placed between the two wooden strips. The carbon plates are placed outside of the strips and held by the two rubber bands, as shown in Fig. 1.

The connection between the carbon plates and the wire leading away from the carbon pole is made by a doubled strip, *a*, of copper, the ends of which are inserted between the wooden strips and the carbon plates. In a similar way a copper strip, *b*, is inserted between the zinc plate and one of the wooden strips. The tumbler forming the battery jar should be deep enough to allow the wooden strips to rest upon its rim, so as to support the plates a short distance from the bottom of the tumbler.

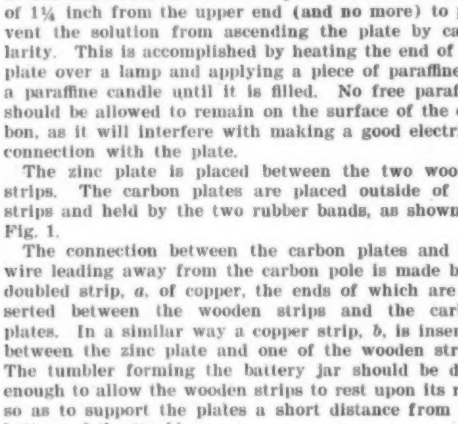


Fig. 2.—THREE CELLS IN SERIES.

The ordinary bichromate of potash solution is used in the battery. It is prepared by making a saturated solution of common bichromate of potash in warm water, then, after cooling, adding very slowly a quantity of common sulphuric acid, equal to about one-fifth of the bulk of the bichromate solution. It is advisable to add to the solution a very small quantity of bisulphate of mercury, say one-eighth ounce to the quart of solution, to maintain the amalgamation of the zinc.

The salts known as the C. & C. battery compound are excellent and very convenient for use in batteries of this class. It is only necessary to dissolve this compound in water to form the exciting solution.

This material is sold in tin cans containing two or three pounds. It absorbs moisture rapidly, so that when it is to be used in small quantities, it should be transferred to a stoppered glass jar.

It is, perhaps, needless to say that great care should be exercised in handling the solution, as it is poisonous and destructive to clothing, carpets, etc. The same remark applies to the battery compound.

One cell of this battery should be allowed for each

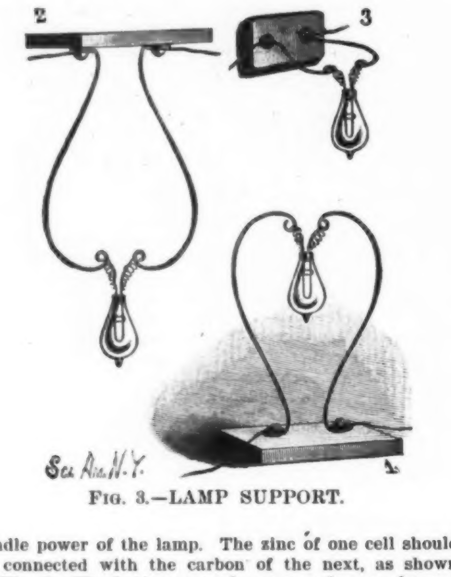


Fig. 3.—LAMP SUPPORT.

candle power of the lamp. The zinc of one cell should be connected with the carbon of the next, as shown in Fig. 2. The battery may be arranged as a plunger. Directions for making a battery of this kind were given on page 116, of volume 57, of Scientific American.

In Fig. 3 is shown a convenient bracket for supporting small electric lamps. It consists of two curved wires attached to a small piece of board by means of screws which also serve as binding screws for attaching the wires. The lamp is suspended from eyes formed in the ends of the wires. This device may be used as a standard, as shown at 1, as a hanger, as shown at 2, or as a bracket, as at 3.

In Fig. 4 is shown a series of three small lamps connected with three cells of battery.

The lamps in this case are connected in parallel or multiple arc, i. e., one binding screw of each lamp is connected with one wire from the battery. The other binding screws of the lamps are all connected with the remaining pole of the battery.

Copper wire, No. 18 or larger, should be used for making the connections. The battery will run continuously with a single charge of the solution for about three hours. Should the solution become warm and give off hydrogen, the zinc should be reamalgamated at the points where it is violently attacked.

STEEL RESEARCHES.

M. Leon Guillet, of Paris, has recently made a number of researches upon the constitution and properties of steel containing tin, cobalt, and titanium, according to the method he has applied successfully in making tests upon special steels. As to the steels containing tin, he finds that from zero to 5 per cent of tin we have the same constitution as for the ordinary carbon steels. At 5 per cent a rather long attack of the metal shows white spots around the perlite which are like those appearing in certain silicon steels. At 10 per cent of tin, the white spots are larger, but there is no trace of graphite. The carbon is in the state of carbide of iron. In short, the tin commences by entering into solution

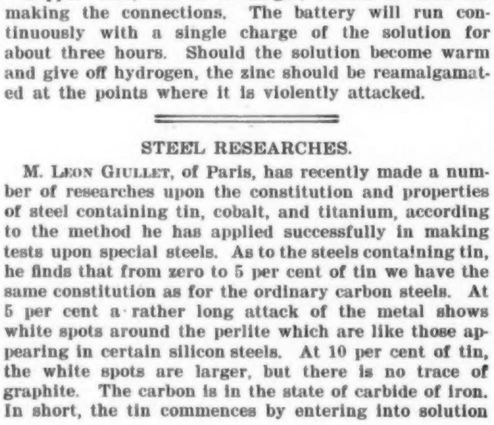


Fig. 4.—LAMPS CONNECTED IN PARALLEL.

in the iron and separates out in a definite compound when saturation takes place. The carbon is always in the state of carbide of iron, at least for values below 10 per cent of tin. The tin steels cannot be rolled when the proportion of tin exceeds 1 per cent. They are then extremely hard and brittle. Annealing has the same effect here as upon the ordinary steels.

In no case he finds the precipitation of carbon in the state of graphite. Tempering only produces martensite in cases where perlite existed already, and it thus appears that the iron-tin compound does not dissolve the carbon. As to titanium steels, he studies these up to a 9 per cent value of titanium. Some of the steels contained but little carbon, and others some 0.7 per cent. In all cases he finds that these steels have the same constitution as the ordinary steels. Micrographic observation seems to show that the titanium enters into solution in the iron. Mechanical tests showed no appreciable betterment of the qualities of the steel, but the steels containing a high carbon value have a higher breaking strain than usual. It seems besides that the ferrite of these steels is harder than that which is found in ordinary steels, as if all the titanium was concentrated there. Annealing has the same effect on the titanium steels as we usually find. Tempering modifies them like carbon steels, presenting a difference, however, in the mechanical properties which is more strongly marked than usual. In short, micrographic study, as well as mechanical tests, of titanium steels shows that this metal has a very slight influence on the properties of steels, and that these alloys present no industrial interest. He then studied specimens of steels containing cobalt up to 60 per cent of that metal. All the specimens without exception are perlitic, and the cobalt does not cause any transformation in the micro-structure of the ferro-carbon alloys. The mechanical properties are besides very slightly modified. However, the breaking strain and the elastic limit increase slowly, while the elongations and strictions are modified in the contrary sense. Cobalt steels show no industrial interest and they are quite unlike the nickel steels. To sum up, his researches show that the three metals titanium, tin, and cobalt enter into solution in the iron and that the carbon of these steels is in the state of carbide of iron, within the limits of these experiments. The mechanical properties of the steels show no industrial use for them, and they show very clearly the difference which exists between tin, titanium, and silicon steels on one hand, and nickel and cobalt steels on the other.

JAPAN'S TRADE.

The remarkable growth of Japanese foreign commerce during the first six months of this year, especially of imports from foreign countries, is shown in the "June Monthly Return of the Foreign Trade of the Empire of Japan," a copy of which official publication has just reached the Department of Commerce and Labor through its Bureau of Statistics.

As compared with the six months' figures for the previous year, the imports show the remarkable increase of 56.9 per cent, from $90,952,000 to $142,659,000, while exports for the same period show a relatively insignificant growth of less than 4 per cent, from $68,458,000 to $71,098,000.

It is of interest to note that, while the largest increases in imports are credited to the United States, the United Kingdom, and British India, the largest increases in exports occur under the head of China, United States, and Korea. Thus, imports from the United States for the first six months of the year 1905 were $31,921,000, as against $13,328,000 during the same period of 1904; imports from the United Kingdom were $32,623,000, as against $16,982,000; imports from British India were $34,034,000, as against $21,092,000; while imports from Germany are stated as $10,794,000 for the first six months of this year, as against $6,985,000 for the same period of the year 1904. As regards imports from other countries, they have increased at a much lower rate, or else show decreases.

The exports during the same periods were largest for China, which is credited with $21,932,000 as compared with $14,953,000 during the first six months of 1904. The United States ranks next among the countries to which Japanese products are destined, the figures for the first six months of 1905 being $20,304,000, as against $19,910,000 for the previous year. In the third place now stands Korea, with $5,852,000, as against $3,840,000 for the same period of 1904. The exports to the other countries are relatively small and, moreover, show decreases. Thus, exports to France, one of Japan's large customers of silk, have fallen from $7,117,000 during the first six months of 1904 to $5,401,000 during the first six months of 1905. The exports to the United Kingdom have likewise decreased from $4,343,000 to $3,335,000, while exports to Germany have fallen from $1,098,000 in 1904 to $1,045,000 in 1905.

The leading position of the United States in Japanese foreign commerce is seen from the fact that this country furnished 22.4 per cent of the total imports during the first six months of 1905 as compared with 14.7 per cent of the total imports during the same period of 1904, and is credited with 28.6 per cent of the total domestic exports during the first half year in 1905 as compared with 29.1 per cent of the total domestic exports of Japan for the first six months in 1904.

The gains in imports affect not only such articles increased consumption of which was to be expected because of the war, such as flour, beans and peas, woolens and worsteds, cotton manufactures, blankets, sole leather, etc., but other articles as well, increased importations of which are the best sign of industrial growth and expansion. Among the latter, the most notable increases are shown by raw cotton, the imports of which have almost doubled in value, by manufactures of iron and steel, machinery, etc.

The only articles of importance the exports of which show decreases during the first six months of 1905, as compared with the same period in 1904, are coal, sugar, and kerosene oil. The decrease in the importation of sugar is most striking, and is probably due chiefly to the higher import duties on sugar imposed last year

the results of which are seen in extraordinarily heavy importations during the year 1904.

The largest two items of importation appear to be raw cotton, about one-third of which is credited to the United States, and rice, the importations of which assumed large proportions for the first time in 1903, and continue to lead all other items, with the exception of raw cotton. About 38 per cent of the total imports of $142,659,000 during the first half of the present year is represented by the imports of the two items just named.

Exports from Japan, as stated before, show but a slight increase during the current year. Of the principal articles of export, raw silk has held its own, while the manufactures of silk show decreased exportations. Exports of both cotton yarn and cotton manufactures show larger figures for the first six months of the current year than for the same period of the year before. The same is true of copper, matches, mats and matting, porcelain and earthenware, and many other smaller items of Japanese produce and manufacture, too numerous to be stated specifically. The largest relative increase is shown by the exports of beer and saké (rice whisky), which have increased about 178 and 264 per cent respectively during the present year.

Decreases of exports for the first six months of the current year appear under the head of coal, tea, rice, camphor, straw plaits, cigarettes, sulphur, etc.

SEWAGE AND ITS DISPOSAL.*

By H. LEMMOIN-CANNON, P.A.S.I., F.R.Met.Soc., etc.; Author of "The Sanitary Inspector's Guide," etc.

THE importance attaching to the efficient disposal of sewage cannot be overestimated, and its suitable treatment plays an all-important part in public health matters.

In the course of this brief article, I shall endeavor, as far as space will admit, to touch upon some of the principal methods now in vogue for its treatment and disposal.

Composition of Sewage.—It would be well to have some idea of the composition of the sewage to be dealt with. This depends upon whether the "water-carriage" or the "conservancy" system is employed in its collection: and, in the former case, whether the rain and subsoil water is admitted to the sewage proper, or is carried off in separate pipes.

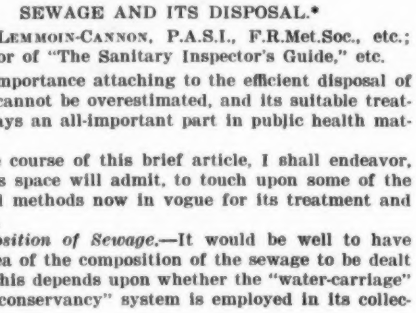


FIG. 2.—LIME MIXER.

In the *water-carriage system*, now mostly adopted in the towns of the United Kingdom, sewage comprises the human excreta (about two to three ounces of solids and two pints of liquid per head per diem, taking an average of both sexes and all ages), waste waters from cooking and cleansing, and from houses generally, including closet flushing; from stables, cowsheds, and slaughterhouses; wastes from manufactories, the washings from streets, etc. A system of drains and sewers is essential to carry the sewage to the "treatment" station. It should be added that the water-carriage system is the most satisfactory one.

In the *conservancy system*, also known as the "interception" or "dry" system, the fæcal matter and waste products from our dwellings are kept separate from the waste waters.

Limits of space compel me to limit my description to the disposal and treatment of sewage in large quantities. I must pass over the methods usually employed in small villages and country houses generally—many of which are not of the most satisfactory character—and proceed to notice the conservancy systems.

CONSERVANCY SYSTEMS.

These systems, still employed in several towns in this country, have been brought about by a process of gradual development from the old-fashioned midden privy, the contents of which were usually allowed to soak away into the adjacent ground. Now a movable pail, tub, or pan is used for the reception of the human excreta in the closets of houses in districts where this system is in vogue, and to this is applied dry-house refuse to assist in its deodorization. These pails or tubs are collected by the local authority at least once weekly, usually at night, in specially constructed vans, the full pail being replaced by an empty one. The vans convey the contents to the depôt for treatment by one of the methods we shall shortly touch upon.

It should be remarked that, in districts where conservancy systems are employed, sewers and drains have still to be constructed to carry off the waste waters from dwellings, stabling, manufactories, street washings, etc.

Various are the kinds of movable pails and tubs employed in conservancy systems for house closets, some being of wood, others of iron. One of the most interesting is known as the "Goux" pail, and is of wood (Fig. 1). Before being sent out from the depôt, a mixture of factory waste and sulphate of lime in certain proportions is applied to the empty pail, and a mold is also inserted which causes this mixture to be pressed against the bottom and sides. The mold is removed when the pail is left at the house. It is claimed for this mixture that not only does it absorb the moisture in the pail, but it prevents decomposition and facilitates the treatment of the excreta in bulk. This pail is used in some manufacturing towns.

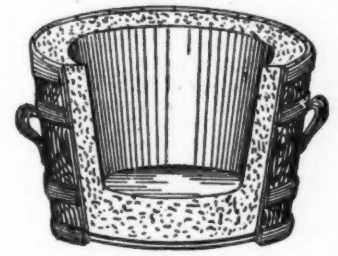


FIG. 1.—GOUX PAIL.

One reason for the retention of conservancy systems in some towns, instead of the adoption of the more sanitary water-carriage system, is that at one time human excreta were considered to be of high value on agricultural land as manure, and the less water the sewage contained the easier would it be to deal with, to render it suitable for this purpose. Experience, however, has failed to support this view, since the human excreta contain such a large proportion of water.

The contents of the pails, when discharged at the depôt, have to be converted into portable manure at a minimum cost; and several methods are adopted for this purpose. A simple one is to add to the sewage two or three times its own volume of dry ashes to absorb any moisture; the mixture is then placed in a "stirring-mill," and a small percentage of sulphate of lime and animal waste are added simultaneously. The coarser portions are next removed by efficient screening, and the residuum is then suitable for placing in bags for sale as portable manure, ten shillings per ton being an average price realized for it.

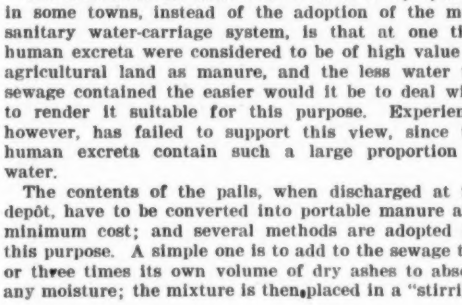


FIG. 3.—FILTER PRESS.

In another method, it is customary to use a long cylinder, with a steam jacket having a hollow shaft so constructed as to admit steam while the cylinder is revolving. After the contents of the pails have been admitted, the cylinder revolves for some two hours, by which time all the moisture is driven off, and the sewage is reduced to about one-twentieth of its former weight. After being allowed to cool, it is reduced to powder and sold as manure.

As regards the prices paid by agriculturists for manure produced from sewage, they naturally vary considerably, the authorities making the best bargains they can with the farmers and market gardeners of their districts.

WATER-CARRIAGE SYSTEMS.

The use of sewage as manure having been at first considered the most sanitary and satisfactory method of disposal, the early attempts at dealing with water-carried sewage were in this direction. On the advice of several prominent sanitarians and agriculturists, what came to be known as "sewage farms" were established in many parts of the country for receiving towns' sewage, the outfall of the sewers being on the farm lands so used.

The land requires to be specially prepared for the reception of the sewage by leveling and under-drainage, and sufficient land must be acquired for all parts of it to be given periods of rest from the reception of the sewage. To make sewage-farming anything of a success certain points have to be studied. A loamy soil is considered the best, and the choice of suitable crops is important. Large crops are frequently grown on sewage-farms.

A financially successful sewage-farm is, however, rare, owing chiefly to the quantity of water diluting the manurial properties in the solids and also the liability of the land to be "clogged." Thus the sewage is insufficiently purified and the liquid escaping from it to adjoining ditches in large quantities is liable to contaminate any brook or stream into which it passes.

THE CHEMICAL TREATMENT OF WATER-CARRIED SEWAGE.

Various methods for treating sewage with chemicals were introduced when experience had proved that the direct application of water-carried sewage to land was not so successful as had been anticipated. The objects aimed at were to eliminate the solid matter, facilitate its conversion into portable manure, and to allow only the liquid sewage to flow on to land.

In all systems of chemical treatment it is necessary to construct what are known as "settling-tanks" for the purpose of receiving and retaining the sewage for a sufficient time to allow the settlement of the solids it contains; afterward the "effluent" (as the top water is called) is allowed to flow on to land for further purification. The solid matter left in the tanks is technically known as "sludge."

To assist this settlement and also to arrest decomposition, to destroy all dangerous organisms as well as to produce a wholesome effluent, various chemicals have been employed for application to the sewage on its admission to the tanks. The size and number of the tanks depend on the quantity of the sewage.

Sillar's A B C Process was one of the earliest introduced to assist in this settlement. A mixture of alum, blood, charcoal (vegetable and animal), burned lime, etc., was mixed with the sewage in the settling tanks, the proportions varying from four or ten parts to one thousand of the sewage, depending on the composition of the sewage to be treated.

Lime as a Chemical Precipitant.—This is one of the most satisfactory, and certainly the most economical, of chemical precipitants. Lime used by itself, however, fails to arrest decomposition; hence various chemicals are added to the lime, according to the nature of the sewage to be dealt with.

One method is interesting. It is employed to deal with the sewage of some 50,000 persons, amounting to about two million gallons daily. Some eighteen hundredweight of sulphate of alumina are first added, followed by a ton of slaked lime. Eight tanks, each having a capacity of some 120,000 gallons, are arranged in parallel, and the effluent passes on to some ten acres of land which is laid out in "filter-beds," under-drained to a depth of six feet; each portion, or bed, is allowed stated periods of rest from the reception of the sewage effluent. From these two million gallons of crude water-carried sewage some seventy tons of solid matter, or sludge, settle to the bottom of the tanks.

In applying lime to crude sewage it should be well "slaked" and reduced to a milky condition by the use of a lime-mixer. Fig. 2 illustrates one of these, fitted with stirring (or agitating) gear and elevator for feeding slaked lime into the pan for the production of the required milk of lime.

Other Chemical Processes.—A well-known one is the *sulphate of alumina* process, in which the chemical employed (called aluminaferic) is made up into large solid cakes of about a half-hundredweight each, and placed in a wire cage in the sewage conduit, near the entrance to the settling tanks. The crude sewage passes through this cage before entering the settling tanks. This is claimed to both assist settlement and to produce a most satisfactory effluent. In hot weather a minute quantity of manganate of soda should be used to prevent secondary decomposition.

In some cases, dependent on nature of sewage, it is necessary to add lime.

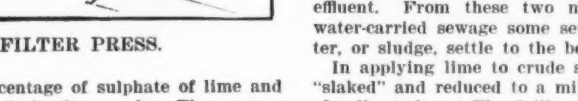


FIG. 4.—SEWAGE FILTER BED.

In the *Amines Process*, herring-brine is added to the lime, so as to destroy the many micro-organisms in the sewage, and also to clarify it; this is a foreign method. In all chemical treatment systems, secondary decomposition must be guarded against. There are several other precipitating agents in use under other systems.

THE TREATMENT OF SEWAGE SLUDGE.

In all chemical precipitation processes a residuum, known as sludge, remains at the bottom of the settling tank. On the addition of the precipitating chemicals to the crude sewage in the tanks, a flocculent precipitate is formed; a part of the dissolved slimy organic

* Technics.

matter is coagulated, and this slowly settles to the bottom. This is sludge. The effluent, or top water, being run off on to land, the sludge requires to be dealt with. Its preparation for sale as portable manure is considered the most suitable way, although its satisfactory disposal is a problem which sewage engineers have found great difficulty in solving.

Despite the fact that it appears practically solid, it still contains some ninety per cent of water. It is to eliminate this that attention next has to be directed; it must be speedily effected, otherwise a process of secondary decomposition sets in and causes considerable trouble.

One of the most satisfactory methods of ridding the sludge of moisture is to treat it in a suitable filter press worked by steam or hydraulic pressure. Fig. 3 illustrates a filter press with thirty chambers. It is fitted with patent air cylinder for closing up, press head, and plates. The distance pieces are shown lifted up, and the head moved back for emptying the cakes into which the sludge has been converted. At each operation a press of this size can produce about ten hundredweight of cake. The sewage should be "screened" before entering the machine. Sludge-rams, usually worked by compressed air, are useful for forcing the sludge into the filter-presses.

The value of the cakes of sludge for manure will depend upon the composition of the sewage, and the nature of the chemicals used in the precipitation; they must, of course, be of convenient size for carriage. It is considered by some to be of the same value as ordinary farmyard manure.

In some places sewage farms are used for the reception of the sewage sludge after it has passed through the press; in such cases it is dug into the land. In towns situate near the sea, where sludge is produced by one of these methods, it is not sold, but loaded into specially-built barges, carried out to sea, and there is discharged in such a position that the currents cannot carry it landward.

The liquid pressed out in the production of the sludge cakes should be pumped back into the precipitation tanks for re-treatment.

Another method of dealing with sludge is to use hydraulic power to remove the excess of moisture, and press it into cakes; these are conveyed to the refuse destructors, to be burned with the ordinary town refuse. A hard clinker is thus produced which, being crushed, is then mixed in a mill with Portland cement. The mixture thus produced is placed in shapes, and subjected to an hydraulic pressure of about 2,500 pounds per square inch, when it becomes converted into very satisfactory paving slabs.

DISPOSAL OF THE EFFLUENT OF CHEMICALLY-TREATED SEWAGE.

As we have observed, the effluent, or top water, on leaving the tank is not sufficiently pure to permit of its entering a brook or stream; therefore various have been the methods employed, and at present in use, for its further purification. Where a sufficiently large area of land can be acquired, passing the effluent through this may be sufficient, but the price of land in a convenient situation is frequently prohibitive.

Specially constructed "filter beds" are therefore most usually employed. One of these, illustrated in Fig. 4, is composed of layers of sand, gravel, fine cinders, or coke breeze; with a depth of 4 feet 6 inches of fluid upon the surface, this will successfully filter the sewage effluent at the rate of five hundred gallons per day per square yard of surface area. It is essential that the beds have periods of "rest" in order to revivify them; the frequency and duration of these rests will depend upon the nature of the sewage effluent to be purified. The top surface of sand, to a depth of about half an inch, requires to be occasionally replaced. A very suitable area for a bed is a quarter of an acre. The effluent passes successively through the various layers in the bed, and, thus purified, on reaching the pipes at the bottom of the filter, passes away into some adjacent stream. Such a filter as this will continue for some years to produce a satisfactory effluent with proper treatment.

Lowcock's System of Sewage Filtration is somewhat of an improvement, but on the same lines. The filter is composed of some seven layers of sand and gravel, the top layer consisting of nine inches of sand, which only allows the sewage to pass very slowly through it, and, at the same time, arrests many matters that may remain in suspension after treatment in the settling tanks. Aeration is very essential to the successful working of the filter, therefore the fourth layer contains air-pipes, into which air is forced by means of a blower. The pipes are so fixed as to allow the air passing through all parts of the filter. At the bottom of the filter are the usual effluent drains through which the purified effluent passes away into a water-course. A portion of the surface sand requires replacing at intervals.

In the "*Polarite*" *Process* the same main features prevail, but six inches of "polarite"—a patent chemical composition—with three inches of sand are laid on the filter-bed, to form the second layer between the top sand and the third layer of pea-sized gravel. The whole has a concrete bottom three feet in thickness. Six hundred and fifty gallons of effluent can be purified by the "polarite" process daily on a square yard of filter-bed surface.

There are other processes employed for the purification of the effluent from chemically-treated sewage, but the three just touched upon will give an idea of the general principles which underlie all.

It is most essential that the distribution of the sewage effluent over a filter-bed be uniform, not only on financial grounds, but also for biological and chemical reasons. To facilitate this, what are known as sewage-distributers for filter-beds have been invented. They aim at distributing the effluent in equal volumes at stated periods over the entire surface of the beds, to allow for any variations in flow, and also to control the rate of this distribution independently of the "head" of sewage, and make it also practicable with no appreciable head.

The Scott-Moncrieff rotating distributer is driven by its own oil motor, which renders it quite independent of the head or volume of the sewage effluent. The bed has a vertical stand-pipe in the center, into which the effluent from the tank flows; a horizontal arm attached thereto is capable of being revolved about the center. The revolving arm consists of a large main trough or carrier, into which the sewage is delivered from the vertical stand-pipe just alluded to. This arm is quite close to the surface of the filter-bed, thus preventing any sewage spray from being blown about by the wind.

This distributer is so constructed that the same amount of sewage can be discharged in a given time over each square yard of the filter-bed, and by this means no portion of the bed is under- or over-worked; thus the rate of discharge (that is to say, the daily amount of effluent poured on to the bed) can be regulated. Intermittent aeration is also provided for. By whatever system sewage is treated, if it requires subsequent filtration through "beds" this distributer can be employed, and it can be constructed to suit any shaped filter-bed.

The Septic System for the Disposal of Water-carried Sewage.—We must finally notice a system of sewage treatment which has come very much to the front during the last few years. It is a complete reversal of all previous processes. Formerly, as we have seen, attention was directed to arrest decomposition in the crude sewage. In the septic system, however, decomposition or putrefaction is encouraged, for which purpose the sewage is confined in tanks from which all light and as much air as possible are excluded. By this process microbes of decomposition are generated, and these speedily multiply, and destroy the solid matter contained in the sewage, and a satisfactory effluent is the result.

PROTEIN IN FOOD.

By J. H. Long.

Many of the advances in physiological chemistry are in lines which are comparatively new. One of these is concerned with the question of protein in nutrition, which has been a much-debated problem for fifty years. Indeed, interest in this goes back to the days of the epoch-making publications of Liebig on the relation of organic chemistry to physiology and pathology, issued in the early forties. In these he developed his idea of the functions of various foods in the nutrition of man and laid particular stress on the importance of protein as the source of muscular energy. According to this early Liebig view our foods may be divided into plastic or tissue-forming, on the one hand, and heat-producing, on the other. The production of heat appeared as an end in itself and the fats and carbohydrates served for this purpose. The protein substances are built up into tissues and in the oxidation of the latter, it was held, we have the sole source of muscular energy. The name of Liebig was all-potent in science in those days and his nutrition theory held sway for twenty years or more without question. It will not be necessary to recount the steps in the opposition which finally developed, but it may be well to recall the famous experiment of Fick and Wislicenus in which, in an ascent of the Faulhorn, in 1866, they calculated the work done and the protein oxidized, as measured by the urea excretion. The protein combustion was found to be far too little to account for the expenditure of work in the climb, which result confirmed the theoretical objections urged, especially by J. R. Mayer, of Heilbronn. Other important investigations followed in the same direction, and almost without exception they have gone to show that while the protein oxidation *may* furnish a part of the muscular energy of the body, or even all of it under certain extreme circumstances, the fats and carbohydrates are the usual sources of such energy in man, and that heat production is only incidental, not an end, but an unavoidable accompaniment. A few recent experiments which have seemed to support the Liebig contention have been made largely with carnivorous animals and have no real bearing on the problem so far as man is concerned.

As a necessary consequence of the Liebig theory it was held that our protein consumption must be high, and hence the large amounts of nitrogenous substances insisted upon in the older dietaries. But after a time physiologists naturally began to inquire into the real uses of protein, if it is not called for in the work of the muscles; if, as appeared evident, it is used mainly in the repair of waste tissues, why metabolize so much, since in this metabolism an enormous amount of extra work is thrown on the oxidizing and excreting organs of the body. It certainly can not be assumed that the disposal of the katabolic products of proteins can be accomplished without using up a considerable amount of energy, and without a great strain on the liver and kidneys. What, then, is the amount of protein actually needed for the normal body? Numerous answers have been given to this question and in late years several investigations have apparently brought the daily protein down to 25 to 40 grammes, or even lower. But it has been urged against all the experiments leading to such results that they were of too short duration to actually prove anything of value. For example, Siven carried out a 32-day test in which the protein metabolized daily was about 38 grammes; during a part of this time the body was kept in nitrogen equilibrium by about 25 grammes daily. Hirschfeld somewhat earlier had made numerous observations in which the protein consumption through about two weeks was 35 to 45 grammes, but fats and carbohydrates brought the diet up to an equivalent of 3,750 to 3,900 calories.

The importance of the subject is worthy of the fullest investigation, and such a study has finally been carried out by Chittenden through experiments, first on himself, and then on groups of men engaged in various occupations. In the first of these remarkable experiments, which have recently been described in book form under the title "Physiological Economy in Nutrition" the distinguished Yale scientist determined in his own case how far he could safely reduce the protein of his diet and still retain the body in nitrogen equilibrium. To do this close watch was held on the food and excreta through a year, November, 1902, to October, 1903, and under varying external conditions of work and temperature. As a result of these systematic tests Chittenden found that he could live very comfortably, and in perfect health, on a diet containing 35 to 40 grammes of protein daily, with fats and carbohydrates sufficient to yield 1,500 to 1,600 calories. These valuable personal experiments were regarded as preliminary only. Later, systematic observations were made with three groups of men, the work being carried through periods of five to nine months for each group.

The first group comprised colleagues of the author of the experiments, Yale professors and instructors. The average protein metabolism here was about 4[illegible] grammes. The second group was composed of soldiers from the hospital corps of the United States army who were detailed for the purpose of the study. Of the twenty who began, thirteen followed the tests through the whole period of over six months. Those who deserted, or were dropped, had much to say through the newspapers about starvation diet, but this was a curious misnomer, since, as the records show, the men who remained were kept in perfect nitrogen equilibrium and found themselves in far better physical condition at the end of the experiments than at the beginning. Through all this time they had plenty of work to perform, with constant and rather severe requirements on the muscular system. The average protein consumption daily was not far from 55 grammes.

Finally, eight Yale athletes showed themselves willing to work through the training and competing season on the restricted protein diet. The results here were equally remarkable, in fact probably the most remarkable, as the work done by these men was of a character to call for very high protein diet according to all of our old standards. The experiments were carried out through a period of five months, February to June, 1904, and through the last two months a very close record was kept of diet, excretion, weight, and various other factors concerning the men. Through this sixty-day period, when the muscular exertion was perhaps the most taxing, protein equilibrium was maintained on an average of 8.81 grammes of nitrogen metabolized for each man daily, corresponding to about 55 grammes of protein. All these men took high rank in athletic work, several of them being prize winners. The reproductions of photographs, published in the book, show them to be men of excellent physique, and even of remarkable muscular development in some cases. While the protein diet of these men was low the fat and carbohydrates were generous but not excessive, the calorific value of the whole being seldom over 3,000 calories.

For all these men under examination in these three sets of tests, professional men, soldiers, athletes, complete statistics for each day are published, from which the reader may derive the fullest possible information. Painstaking accuracy is evident in every page, and from the standpoint of logical requirement in experimental proof the tables meet any reasonable objection.

This Chittenden investigation then must be regarded as of fundamental importance, as it demonstrates beyond cavil just what is possible in protein restriction under ordinary conditions. The periods of investigation chosen were long enough to answer objections to the results of some of the earlier tests, and the values obtained for the soldiers and athletes of about 55 grammes of protein metabolized daily will have to be taken as practical standards. It doubtless remains true that for men at severe work at low temperatures a large number of calories are required in food. An instructive example of such dietaries is given in the recent publication by C. D. Woods on the diet of Maine lumbermen, where it is shown that the heat value of the food consumed daily by men in the lumber camps may amount to 6,000 or 8,000 calories. It would be interesting to experiment in such cases on the replacement of a good share of the protein by fat and carbohydrates.

A study of the Chittenden series of experiments on men shows very clearly that as far as the human organism, at any rate, is concerned, the old Liebig notion of the source of muscular energy is without foundation. As suggested above, experiments with carnivorous animals do not apply to man; it would be as justifiable to discuss the food value of pentoses for man from experiments on the feeding of straw to

cattle. It is true that for short periods, or under special conditions, proteins may serve man as the main or only source of muscular energy, but evidently this is not usually or normally the case.

When the far-reaching importance of the whole question is realized, and when it is further remembered that considerable internal work must be done to remove, especially, the products of protein metabolism, I believe it will be granted that I am right in placing this work of Chittenden among the most important recent achievements in physiological chemistry.

SCIENCE NOTES.

It seems clear that we have much to learn as to the nature of all the forms of energy, and one appears to be as mysterious as any other, though some of them, like gravitation, are so common and so constant that they awaken no curiosity in most persons and seem to be quite unrelated to personality or to philosophical and religious matters. It seems probable that whoever shall find the meaning of any of these factors will have at hand means for the disentanglement of the whole. With all these problems to be solved, is there not enough for the work of the century? And whoever shall catalogue the triumphs of the twentieth century, if he can point to all these or a good part of them will have reason for holding that this century has accomplished as much and as important work as did its predecessor, the nineteenth.

We have only just discovered that a few weeks ago Prof. Karl Pearson propounded the following problem: "Supposing that a man set out for a random walk, and after walking equal lengths in straight lines turned suddenly at right angles to the previous direction—thus he might turn either to the right or to the left—and then walked the same set length in a straight direction, turning at right angles at the end of that set length, at what distance would he be after a certain definite time." The problem has happily now been not merely understood, but solved. Wild horses would not drag from us more than the bare result, which, *mirabile dictu!* is that the man would be just where he started from. Clearly, children who are taken to disport themselves in, say, Central Park, should be taught to gambol in the way indicated in the problem.

The preparation of wood-stone is of interest from its furnishing an employment for sawdust. It is an agglomeration of wood sawdust and calcined magnesia reduced to powder, with thorough mingling accomplished by the humid method. The material is pounded and ground, and then compressed, at first slowly, with light pressure in a preparatory press, and then for eight consecutive hours in a machine capable of developing a pressure of 1½ kilogrammes. The finished products are then subjected to the action of the hydraulic press. They are incombustible, impermeable to water, and susceptible of taking on a polish, which allows of their use in ornamentation. Employed for pavements, linings, or coverings, they are capable of supporting in the different cases the following rupture charges: To flexion, 439 kilogrammes per square centimeter; to tension, 251 kilogrammes; to compression, 854 kilogrammes.—Le Bois.

M. Moissan has recently published researches, conducted in collaboration with M. Charbennes, on certain physical constants of pure methane, and on the combination of solid methane and liquid fluorine. The methane gas was obtained by the action of cold water on aluminum carbide; it was liquefied, and then solidified. After a vacuum on ice was produced, a disengagement of a gas occurred under progressive reheating; this was considered as very pure. The density of the gas was found to be 0.554, which is almost identical with the theoretic density. M. Schloesing had previously deduced by a special investigation the figure 0.558. The fusing temperature of solid methane is —184 deg. C. The boiling point is —64 deg. These figures are quite different from those indicated by M. Olzewski. Finally, if the liquid fluorine is introduced into a tube containing solid methane at —187 deg. C., a brilliant light, accompanied with a violent explosion, occurs. This reaction furnishes a new proof of the opinion that chemical affinity may subsist at a very low temperature.

The composition of soils varies greatly in different localities and in quite limited areas. Our soils were nearly all fertile originally, but continued cultivation has in many cases reduced their powers to grow crops as they did when first brought under the plow. The best methods of restoring soils that have been cultivated too long is a pressing question not only in the older settled States, but is insistent in most of the newer lands of the West where wheat has been grown until profitable crops of it are no longer to be had. Rotation of crops and laying down in pastures to be grazed until the soil fills with roots is the well-known restorative, but soils vary greatly in our several States and are adapted to the growth of special crops in our several latitudes, so that a general knowledge of their composition is of prime importance before the tiller can put them to their most profitable uses. Droughts limit the yield on soils that have lost their organic matter through continued cultivation without an adequate return of fertilizers in the shape of decaying vegetation. Commercial manures will not adequately remedy the evil, as they do not return to the soil what enables it to retain moisture. Soils vary so much in this regard, from coarse sand to retentive clay, that each requires careful study to enable the farmer to manage it to the greatest advantage.

TRADE NOTES AND RECIPES.

"Perepusk."—Under this name are sold at Moscow, and even at St. Petersburg, artificial butters, which are used to a considerable extent. According to J. J. Petrow, in the Rigaer Industrie Zeitung, these products are produced from the following receipts, which give the proportions used in each case:

	1	2	3
Fresh butter	150	100	50
Animal fat	80	100	150
Sunflower oil	40	80	80
Cocoanut oil	30	20	20

It is seen that these three varieties contain respectively 50, 33, and about 16 per cent of cow's butter, which is sold at 9 rubles, 8 rubles, and 7 rubles respectively per pood, the illicit profit amounting to about 30 per cent. The appearance of the mixture is so nearly perfect, and the acid number so near that of natural butter, that the detection of the fraud is difficult.

To protect ropes, cords, and cloths made of flax and hemp against rot, it has been recommended to leave them for four days in a solution of copper sulphate, 20 grammes to a liter, then allow them to dry, and then, to prevent the copper sulphate being washed away by the water, place in tar or a solution of soap —100 grammes to a liter. In the latter case an insoluble copper soap is formed. To secure the same result with twine, the following process has been recommended: Place the string for an hour in a solution of glue, then allow to dry, and place in a solution of tannin. After removal from the tannin, again dry, and soak in oil. The process first described has been shown by experience to be very effective; but to prevent the washing away of the copper sulphate, it is advisable to use the solution of soap in preference to the tar, as articles steeped in the latter substance are apt to become stiff, and consequently brittle. The treatment with glue and tannin in the second process has the drawback that it tends to make the string too stiff and inflexible, and thus impair its usefulness.—Die Fundgrube.

Product for Cleansing and Restoring Polished and Varnished Surfaces of Wood, Stone, and Other Objects. —This is composed of the following ingredients, though the proportions may be varied: Cereal flour or wood pulp, 38½ per cent; hydrochloric acid, 45 per cent; chloride of lime, 16 per cent; turpentine, ½ per cent. After mixing the ingredients thoroughly in order to form a homogeneous paste, the object to be treated is smeared with it and allowed to stand for some time. The paste on the surface is then removed by passing over it quickly a piece of pliant leather or a brush, which will remove dirt, grease, and other deleterious substances. By the application of a little friction with a cloth or piece of leather a polished surface will be imparted to wood, and objects of metal will be rendered lustrous.

The addition of chloride of lime tends to keep the paste moist for a considerable time whatever the temperature, thus allowing the ready removal of the paste without damaging the varnish or polish, while the turpentine serves as a disinfectant and renders the odor less disagreeable during the operation.

The product is rapid in its action, and devoid of ingredients which might affect the varnished or polished surfaces of wood or marble. While energetic in its cleansing action on brass and other metallic objects, it is attended with no corrosive effect, and is an excellent disinfectant.—France Horlogère.

Luminous Paints.—The illuminating power of the phosphorescent masses obtained by heating strontium thiosulphate or barium thiosulphate is considerably increased by the addition, before heating, of small quantities of the nitrates of uranium, bismuth, or thorium. Added to calcium thiosulphate, these nitrates do not heighten the luminosity or phosphorescence. The product from strontium thiosulphate is more luminous than that of the barium compound. The best luminous paints are the following:

1. Lennord's.—100 grammes of strontium carbonate, 100 grammes of sulphur, 0.5 gramme of potassium chloride, 0.5 gramme of sodium chloride, 0.4 gramme of manganese chloride. The materials are heated for three-quarters of an hour to one hour, to about 1,300 deg. C. The product gives a violet light.

2. Mourel's.—100 grammes of strontium carbonate, 30 grammes of sulphur, 2 grammes of sodium carbonate, 0.5 gramme of sodium chloride, 0.2 gramme of manganese sulphate. The method of treatment is the same as in the first, the phosphorescence deep yellow.

3. Vanino's.—60 grammes of strontium thiosulphate, 12 cubic centimeters of a 0.5 per cent acidified alcoholic solution of bismuth nitrate, 6 cubic centimeters of a 0.5 per cent alcoholic solution of uranium nitrate. The materials are mixed, dried, brought gradually to a temperature of 1,300 deg. C., and heated for about an hour. The phosphorescence is emerald green.

4. Balmain's.—20 grammes of calcium oxide (burnt lime) free from iron, 6 grammes of sulphur, 2 grammes of starch, 1 cubic centimeter of a 0.5 per cent solution of bismuth nitrate, 0.15 gramme of potassium chloride, 0.15 gramme of sodium chloride. The materials are mixed, dried, and heated to 1,300 deg. C. The product gives a violet light.

To make these phosphorescent substances effective, they are exposed for a time to direct sunlight; or the Heraus mercury lamp may be used. Powerful incandescent gas-light also does well, but requires more time.—J. Gaus and L. Vanino, in Journal für Praktische Chemie, 1905.

ENGINEERING NOTES.

The French military department is constructing at the government arms factory of St. Etienne a new type of mitrailleuse. This weapon is far more powerful than the existing type, its firing capacity being 300 shots per second, with a maximum range of 5,400 yards. The tests with the weapon have proved highly satisfactory, except for a natural tendency to become heated through continued discharge, but this defect is being remedied.

Employment of Iron Alloys in Germany.—A modification has been made in the use of ferro-silicium in the steel works. While previously ferro-silicium of low percentage was only required, now the demands include the highest percentages. Ferro-silicium of 25 per cent has been found too difficult of fusion to be employed directly, while that of 50 per cent has a porous structure, allowing of pulverization and of employment. For ferro-chrome used for the production of armor plates, the Krupp factories are said to be now making use of crucible ovens, and not electric furnaces. The Neo-Metallurgie Company, a French company in Germany, produces ferro-chrome of 0.5 per cent containing 2 per cent of carbon, which, it is said, finds a ready market, notwithstanding its high price.

Aeromotors.—M. Sohie, a Belgian engineer, has published in the Annales des Travaux Publics de Belgique his views of the proper installation of a wind motor for the raising of water. The apparatus is composed essentially of a motive wheel with governor, a system of toothed wheels transmitting the movement of the wheel to the piston of the pump, and a tower containing the mechanism. The points that should be examined are: (1) Estimation of the work to be accomplished by the motor at the most unfavorable period. (2) Determination of the position and height of the motor, so as to utilize the greatest force possible. The diameter of the wheel is fixed by the following formula:

$$D = 13.6\sqrt{\frac{\delta h}{V^3}}$$

in which δ is the number of cubic meters of water to be raised to h meters in height; and V the average velocity of the wind in meters per second.

The British Admiralty, impressed by the possibilities of internal-combustion motors for the propulsion of small craft, is carrying out experiments with a view to evolving a power boat suitable to naval requirements. Owing to the inflammability of alcohol and gasoline, and the fact that it would be highly dangerous to carry such volatile fuel on board a battleship, these combustible mediums have been entirely discarded. It is anticipated that an efficient substitute for these fuels will be obtained with a higher flash point, but yet superior to the heavy-grade oil that was experimented with some time ago. The boat is to be capable of putting to sea in any weather. It is to be of stout construction, and able to withstand heavy waves, and at the same time sufficiently strong to withstand the strain of being hoisted on board the deck of a battleship. It must also be capable of sufficient tonnage to carry a torpedo with its attendant discharging gear. The department is also carrying out experiments with motors for auxiliary purposes on board a battleship, such as the driving of electric lighting gear, so that in the event of a breakdown of the main machinery a reserve of power may be available for the supply of light.

March of Industry in Well-nigh Inaccessible Places. —An important problem of the time bears on wresting the wealth of nature from hitherto inaccessible points. Aerial cables, spanning ravines and precipices, are no longer creatures of fancy. One of the most remarkable has been established in France at Salon-Bonabi, in the Pyrenees, on the Spanish frontier. The forest extends beyond the Spanish line for a considerable distance and affords valuable timber, but on account of its altitude, from 1,400 to 2,300 meters, and the difficulty of access, in an uninhabited region, far from usual means of communication, an attempt at exploitation which had been made was abandoned as impracticable. Now, by means of new installations, the wild territory is emerging from solitude and silence. A village has sprung into existence as by enchantment. Sawmills and forges are to be seen in proximity to the habitations of woodmen and mechanics. Dynamos have been established, furnishing current for various purposes. A canal 800 meters in length brings the *houille blanche*, or glacial water power from the Parosa, with a fall sufficient for the necessary turbines which supply the energy. The aerial carrier is composed of smooth cables built up of steel wires, and is held by stout upright supports imbedded in the rock, sometimes as much as 30 meters in height. This aerial line stretches over the irregular mountains at dizzy heights, with spans sometimes reaching 900 meters. Large trunks of trees, often 12 meters in length by 0.80 meter in diameter, weighing a ton and a half, are transported to a center, whence they are conveyed to other points for purposes of construction or for the manufacture of wood pulp. There is a station at each end of the line, and two intermediate stations. The conveying capacity is 14 tons per hour, but the arrangements admit of doubling this figure. Le Monde Moderne, from which we condense these facts, states that the success of the enterprise is assured, that while the cost of the plant has been considerable, the working expenses are low, and that the example is likely to be followed in opening to industry other points of difficult access, far from railways and navigable streams.

ELECTRICAL NOTES.

The French military department is resuming last year's experiments of connecting several of the various great military encampments, distributed over the country, with Paris by wireless telegraphy. In the capital the Eiffel tower will be made the center of operations. Communication therefrom will be systematically carried on for a considerable period with Chalons, Verdun, and other places. The results will afterward be carefully studied by the war officials and the department of posts and telegraphs.

Dr. Max Reithoffer, professor in the Technical High School of Vienna, in conjunction with Herr Karl Morawetz, the government inspector of clocks, has completed a system for synchronizing clocks by means of wireless telegraphy. The plan has been submitted to the city council, and permission has been secured for regulating the public clocks by this agency. The city clocks are to be served free by the system, but for synchronizing private timepieces a small fee will be levied.

It has been shown that carbon is capable of conversion into its various forms, a fact industrially utilized with great advantage by the International Acheson Graphite Company in making graphite and graphitized electrodes from the ordinary forms of coal and coke. Moissan has demonstrated the possibility of changing carbon into the diamond, and has reproduced, artificially, all the variety of diamonds which nature furnishes, alike in all respects save size. It remains for the engineer to operate this process on a large scale to produce exact equivalents and to duplicate not only the diamond but other gems.

The fusion of quartz has produced a valuable material for a new kind of glassware which is indestructible by rapid or extreme variations of temperature. Various refractory materials have their refractory qualities increased by melting and subsequent cooling. Experimental investigation in this direction has only begun, but the results already obtained point to many improvements which may be made in materials for furnace construction, materials resistant to chemical corrosion, and materials possessing high heat and electrical insulating properties. The volatilization of elements and compounds at high temperatures gives new methods for the purification and separation of materials, enabling the process of fractional distillation to be applied to all substances.

An addition of aluminium quite noticeably reduces the hysteresis loss of steel, while it increases the electric resistance, and thus reduces at the same time the eddy current loss. It has been found, too, that an addition of aluminium will reduce the maximum induction and the permeability for ordinary saturation values. The general conclusion is, therefore, that an addition of aluminium improves sheet material which is to be used for constructing dynamos. As regards cast steel, the matter is different. With such a high percentage of aluminium as is required in order to increase the electric resistance to an effective degree, the magnetic properties will be too much affected, and it must be agreed that the usefulness of aluminium in cast steel is questionable, to say the least. It is of interest, however, to notice the results obtained from the researches on cast-steel rods containing both silicon and aluminium. In this case low hysteresis losses are found, to be ascribed, no doubt, to the influence of aluminium, while the influence of this element on the permeability and maximum induction seems to be neutralized by the addition of silicon. The addition of silicon and aluminium together seems thus to tend toward a general improvement of the magnetic properties.

The telegraphs department of the French government has been carrying out a series of experiments between Paris and Rouen with the invention devised by Prof. Korn, of Munich, for the telegraphic transmission of photographs, drawings, and so forth. This system is based upon the property of crystalline selenium, its sensitiveness to light, and the fact that its electrical resistance, according to its exposure to light, is considerably less in the light than in the dark. For transmitting the image there is a selenium cell comprising a slate cylinder wound with platinum wire and covered with selenium, mounted on an axis. This is placed within a glass cylinder, upon which is fastened a negative film of the image to be transmitted. A beam of light is thrown upon this film from an electric lamp, the rays of light being collected and converged upon the film by means of a lens. In this manner the light is transmitted through the film, and affects the electrical resistance of the selenium cell according to the amount of light which passes through the film. From the cell extends the wire to the receiving station, along which the varying current is transmitted. There is a small motor which rotates the glass cylinder upon which the film is fastened, with a corresponding sliding oscillating movement, so that the ray of light is brought to bear upon all parts of the film. At the receiving station the apparatus comprises another cylinder, which is rotated synchronously with the cylinder at the transmitting point. This receiving cylinder is covered with a sensitized film. Beside this cylinder is a small Geissler tube incased in a dark cover and with a small longitudinal orifice at one point. The variation of the electrical resistance of the selenium cell at the transmitting station acts upon this Geissler tube, and the variations of light projected upon the revolving sensitized film produce the image. Several photographs have been transmitted in this manner, and have been received successfully.

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